Popular Astronomy.

Vol. IV. No. 7. JANUARY, 1897. Whole No. 37.

BENJAMIN APTHORP GOULD.

ASAPH HALL.

FOR POPULAR ASTRONOMY.

Dr. Gould was born in Boston Sept. 27, 1824. He fitted for college in the Boston Latin School, and graduated from Harvard in 1844. After a short experience in teaching he decided to devote his life to astronomy, and in 1845 he went to Europe in order to become familiar with the best methods of investigation in his chosen science. He visited and studied at the Observatories of Greenwich, Paris, and Berlin; where he formed acquaintances and friendships that continued during his life. At Greenwich he found Mr. Airy, who had introduced so much order and business method into the management of that famous Observatory. At Paris he studied at the Observatory under Arago, and was a companion student of Faye; but it was in Germany that Dr. Gould found the teachers who pleased him most. These were Encke, Peters, Hansen, and especially the eminent Gauss, one of the foremost men of his age in pure and applied mathematics. At that time Bessel was near the end of his great career in astronomy, but he had marked out the courses to be followed, and his pupil Argelander was carrying out his plans. Dr. Gould caught the spirit and methods of these men, and returned to his native country zealous to see established here those better methods of astronomical research which Gauss and Bessel had developed in in Germany. To this end he labored during the forty-eight remaining years of his life with a steadiness of purpose that never faltered. He spared neither time or money in the advancement of his science. Feeling that a journal devoted exclusively to original observations and researches in astronomy would be an aid in this work he founded the *Astronomical Journal* in 1849. A publication of this kind could not from its nature be other than a pecuniary loss, and the editing was done at a serious outlay of time and labor, but Dr. Gould carried on the journal to the day of his death. The *Astronomical Journal* has now entered its seventeenth volume, and it is to be hoped that it may be continued and supported by the astronomers of our country, and that it may fulfil the wishes of its generous founder.

Dr. Gould immediately became one of the leading astronomers of our country. He was constantly at work, and the list of his publications would be very long. It will be sufficient to mention here some of the most important, and we must omit notice of his minor articles, reviews, and addresses, which are numerous, always well written, and testify that he had few idle days. In 1852 Dr. Gould took charge of the longitude department of the U. S. Coast Survey, and held this position fifteen years. He was quick to recognize the advantages of the telegraphic methods in the determination of longitudes, and assisted in bringing this method to its present accurate condition. As soon as the transatlantic cable was laid he was ready with his corps of assistants, and while some astronomers were considering the practicability of obtaining the longitude from Greenwich in this way, Dr. Gould had applied the new method and found a result which can never be essentially altered. Among his deductions in this connection is the velocity of the electric current.

In 1855 Dr. Gould took charge of the Dudley Observatory at Albany, and equipped the Observatory with instruments and a corps of assistants. A dispute about the management ensued, Dr. Gould resigned, and the Observatory fell into an idle condition, now happily removed. In the mean time the needs of the Coast Survey for accurate positions and proper motions of the stars used for its determinations of time and latitude led Dr. Gould to undertake the formation of a catalogue of such stars from all the data available. This work was finished in 1861 and immediately became a standard catalogue. It contains the first application of a set of systematic corrections to the various catalogues in order to reduce the positions to a normal system of standard stars. During these years he had reduced the observations made by D'Agelet at Paris in the years 1782 to 1785. These reductions, and a catalogue of the stars, are printed in the memoirs of the National Academy of Sciences for 1866. During the civil war Dr. Gould conducted a long series of measurements on the heights, ages and peculiarities of the soldiers and his work has become an interesting book of reference. He took an early and active part in the application of photography to the attainment of exact results in astronomy. His last memoir printed by the National Academy is on this subject, and some of his last days were given to the reductions of the photographs of clusters of the southern stars.

The great work, however, of Dr. Gould in his chosen science, and that which will place his name high in the annals of astron-

omy was done in the southern heavens. The northern stars had been observed and catalogued for a century; while comparatively but little had been done in the southern hemisphere, except the rather limited work of the Observatories at the Cape of Good Hope, and in Australia. The need of a great catalogue of the southern stars, and of accurate determinations of the positions of many of them, in order that astronomers of the future might have the data for complete investigations of the stellar motions was great. Dr. Gould felt this need, and at Cordova in the Argentine Republic, he undertook and carried to completion in fifteen years one of the greatest works of modern astronomy. This work consists of zone catalogues of 73,160 stars between the parallels of 23° and 80° south declination; and in a general catalogue of 32,448 stars, the positions of which are accurately determined by observations with a meridian circle. A work of this magnitude could be observed, reduced and printed, in so short a time only by the most persistent and unflinching labor, which must have been conducted with great care and foresight. The results are embodied in fifteen quarto volumes, with introductions in both the Spanish and English languages. Besides these catalogues there was made an accurate survey of the magnitudes of the stars of the southern heavens down to the seventh magnitude. This determination of the magnitudes forms the *Uranometria Argentina* and was published in 1874. It is the standard of reference for the magnitudes of these stars. And this does not comprise all the activity of those fifteen years, for Dr. Gould had a large number of photographs taken of clusters of stars in the southern hemisphere, and brought these photographs home for future measurement and reduction. He established also a system of meteorological observations in the Argentine Republic, which is still carried on; and, apparently as a little by-play, he connected the longitude of Buenos Ayres, found from the transatlantic cables, with the longitude of Santiago in Chili, determined through the cables down the west coast of South America, closing the last link in this chain with an excellent result. When it is known that this vast amount of bodily and mental labor was accomplished in the short space of fifteen years, and that many of the assistants had to be trained for the Observatory at Cordova, it will be readily understood that Dr. Gould and his faithful assistants must have devoted themselves with the utmost energy to the completion of their chosen work.

A life so full of scientific results brought Dr. Gould many academic honors. He was one of the original members of the Na-

tional Academy of Sciences, established by Congress in 1863. Besides being a member of most of the scientific societies of our own country Dr. Gould was an associate of the Academies of Paris, Berlin, Vienna and St. Petersburg, and of the Royal Astronomical Society of London. He was the recipient of medals and awards of merit.

A man who fills up such a large measure of solid work must have fortunate surroundings, and this was the case with Dr. Gould. He had a strong, vigorous body, excellent abilities, and a resolute will. He was fortunate in his birth and education. In 1861 Dr. Gould married Mary Apthorp Quincy, daughter of Hon. Josiah Quincy. She was a talented woman, and a brave and devoted wife. Mrs. Gould died in 1883, and the catalogue of Southern Stars is dedicated to her "beloved and honored memory." Three children are living, two daughters and a son.

I became slightly acquainted with Dr. Gould in the years 1857 to 1862, while a student and an assistant in the Harvard Observatory. Our acquaintance was renewed and became more intimate after his return from Cordova in 1885. He was a man in whom there was a good deal of the Puritan. He was upright, honorable, and had the courage of his convictions. He hated all shams and pretension. At times he was impatient with what seemed to him stupid objections to improvements in scientific methods, but he soon recovered his equanimity and waited with confidence. He had been for many years a member of the international commission on weights and measures, and was an ardent advocate of the metric system. The objections to this system sometimes provoked him to sarcasm, but he remembered how slowly the world of affairs is changed. I shall always remember the kind letter Dr. Gould wrote me when I sent him my first contribution to the *Astronomical Journal*. Nothing seemed to please him more than to help one of his young countrymen to undertake the serious work of astronomy.

Dr. Gould died Nov. 26th, 1896. I saw him a short time before the accident that caused his death. His eyes were bright, his face cheerful, and he looked like a man with many years of work before him. He followed me out of his door, talking earnestly about some astronomical computations that he wanted pushed forward. A few hours more and the strong man was at rest.

1896, December 5th.

THE LIFE AND WORK OF DR. GOULD.

S. C. CHANDLER.

Somewhat more than a week has passed since the sods were placed over the honored grave of Dr. Gould: yet, even in the busy haste of our American life, there are many who will welcome an appreciative account of the life and achievements of this eminent astronomer. So many notices of him were printed in the daily journals immediately after the community was apprised of its sad loss, that it is unnecessary here to recount the details of his work. But it may be of service to give, in right perspective, a just idea of the magnitude and character of his contributions to astronomy, to speak of the purpose and importance of what he accomplished for science, and of the nature of his strong personal influence in its advancement.

Considered apart from the great things he accomplished, the first thing that strikes us about his career is the intimate way in which it is bound up with the history of his beloved science on both sides of the Atlantic, and the unique position he held as illustrated by the number and extent of his personal alliances. It is scarcely possible to realize that he was the friend of von Humboldt, then in his 77th year: that it was due to the friendly interest of this great man, indeed, that he became the pupil, friend and intimate in the household of the great master of modern astronomy, Gauss, then in his 70th year; that he was the pupil of the illustrious Encke, of the elder Struve, of Peters and Hansen and Argelander—and the life-long friend of these and other revered men, pillars of the science. His correspondence with them after his return to his native land testifies to the mutual confidence that characterized these memorable associations. Following these, in the next generation, come Winnecke, Schönfeld, Auwers, and a host of others, which to us are great names, but to Gould were fellow-pupils and associates. Of the same epoch, on this side of the water, we have Bache, Pierce, Walker, Hubbard, Coffin, Chauvenet and Winlock. Then come the two existing generations of astronomers, bringing friendships and acquaintances wide as the world itself, extending his relations to the youngest workers in the science. With such universal and intimate connection with the personal forces operating to advance astronomy in all lands, with his intense patriotism, with his positive intellectual and moral traits, he could not fail to exercise a powerful moulding influence upon the development of American

astronomy, in correcting wrong tendencies and establishing right standards. It was to this end, in preference to the satisfaction of ambition through what he could accomplish by his personal contributions to the fund of knowledge, that his most earnest efforts from the beginning of his career, were directed. In one of his letters to von Humboldt, in 1850, after speaking of the dependent condition at that time of science here, its self-distrust and intellectual timidity—he says:—"This I knew before returning home, but realize it now, for the first time to its full extent. Therefore it is, that I dedicate my whole efforts, not to the attainment of any reputation for myself, but to serving, to the utmost of my ability, the science of my country—or rather as my friend Mr. Agassiz tells me I must say, science in my country." And to Encke he says, speaking of the establishment of the *Astronomical Journal*, and his fond hopes in its agency as a means of raising the astronomy of America to its proper position:—"Though the labor of supporting it will prevent me from working as I otherwise should for the advancement of my own reputation, still the consciousness that I may render now a still greater service to science reconciles me to the abandonment of a good deal of personal ambition." The same spirit breathes throughout his correspondence with Gauss, Schumacher and other leaders abroad, to whom he was wont to confide his projects and aspirations, and who sympathized with and counseled him in return. His letter-books are rich with similar illustrations. They form indeed a treasure-house of information relating to the inner history of the beginnings of astronomy in the United States. How humble these beginnings were few realize. Astronomy here has made such wonderful strides within a few decades past that it is hard to believe that, with a few brilliant exceptions, its record about the year 1840 was practically blank. We had then no standing among the scientific nations. The soil for its growth was not indeed sterile, but its cultivation had scarcely begun. If the right seed had not been sown we should have had occasion to deplore today the same stunted crop which, even in some countries of far older civilization than ours, stands in place of the rich harvest that might have been gathered, under more favoring influences. And this brings us to another remarkable feature of Gould's career. If we were asked to place the finger upon the one epoch marking the birth, or regeneration of American astronomy, we should feel inclined to name the date, July, 1845, when Gould placed his foot upon the steamer from Boston with the avowed and definite purpose to devote himself to a life of purely scien-

tific research. Up to that time the instance of a man doing this as his only aim, while unassured of a professor's chair or similar appointment, and not as a means of livelihood, was in this country absolutely unknown. With a steadiness of purpose singular in so young a man, he pursued diligently the opportunity he had himself created—a year each at Berlin and Göttingen, and shorter periods at Altona, Gotha, Greenwich and Paris—and returned home, full of early honors, and flushed with lofty hopes and honorable ambitions.

From this point Dr. Gould's life became one of incessant activity, impressing its mark in many ways upon the intellectual life of the community; but the line of intensest force naturally took the direction of his own beloved science, to which he communicated an impulse not measured merely by what he accomplished for it by his direct investigations, great as that is, but also by the force which always emanates from so earnest a nature. He inspired a new breath into American astronomy. The new atmosphere which he brought with him from Germany, where he had caught the spirit of the great masters under whom he studied, became gradually transfused upon this side the sea. His enthusiasm for the introduction of better means and methods of research was caught by his compatriots, their courage to regenerate our science was sustained, and transmitted through various channels to the next and to the present generation. Thus we may say without fear of being controverted that American astronomy today is a different thing from what it would have been without Gould's predominant influence, deep and quiet but strong, to upbuild it and to free it from the clumsiness and imperfections which still impede it even in some of the otherwise most enlightened nations of the world. It is under his leadership that American astronomy has climbed to where it looks with steady and level eye upon that of Germany, which occupies perhaps a larger, but not a loftier plane. It is his example which will stimulate it, in its upward course during the new century nearly upon us, to attain first, in the friendly and honorable national rivalry, the heights commanding all. We cannot presume to say how far the good fortune which has secured our astronomy so exalted a place, has been shared by other branches of physical, or of natural science in our land: or, if so, whether it can be traced to any similar instrumentality. But there can be no doubt that, so far as astronomy is concerned, this enviable position has been reached, and that among the personal influences contributing to that result, Gould's may be justly regarded as preeminent.

Let us now glance at Dr. Gould's more prominent labors, passing by his earlier important investigations in applied theoretical and in practical astronomy, as well as his numerous and valuable contributions to the literature of science, education and other departments of thought, which we find scattered through the long range of his career. In 1852 he was appointed to take charge of the longitude-determinations of the Coast Survey. He organized, developed and extended this service, retiring in 1867. Meanwhile, in 1855, he became director of the Dudley Observatory in Albany, equipped and organized the institution, and carried it on without remuneration and at his private expense. He left it in 1859, after a severe struggle to preserve the institution for purposes of scientific investigation.

In 1859 he published his discussion of the places and proper motions of circumpolar stars, for use as standards in the Coast Survey. These, as revised by him in 1861, together with his similar list of clock-stars, were adopted as the standards for the American Ephemeris, and, as to the circumpolars, remain in such use to this day. In 1866 he published his reduction of D'Agelet's observations. About the same time he performed a similar service for the greater part of the observations made at the United States Naval Observatory since its establishment, as he had done also, several years previously, for the expedition to Chili to determine the solar parallax. In 1866 he planned and executed the work of establishing, by the Atlantic cable, the relation in longitude between European and American stations, involving, as a part, interesting researches on the velocity of the galvanic current in submarine cables, similar to those he had already made on land-lines. As actuary of the United States Sanitary Commission he conducted, and published in a large volume, extensive and important researches upon Military and Anthropological Statistics and the Distribution of Population. About the same time he undertook the reduction of Rutherfurd's photographs of the Pleiades. The results, partially published in 1866, were submitted completely, in an elaborate memoir, to the National Academy in 1870, together with a second memoir on the Praesepe. He was, indeed, a pioneer in the utilization of photography for exact astronomical measurement. About 1864 he built an Observatory in Cambridge, equipped with an 8-ft. transit-instrument, and, until 1867, carried on a determination of the right ascensions of all the stars to the tenth magnitude within one degree of the pole. The work was completely reduced, but the discussion and publication were postponed by his removal to Cordoba.

In 1865 he became intensely impressed with a desire to explore the southern celestial hemisphere. The opportunity to do so soon came. This project assumed at first the form of a private astronomical expedition, for which his friends in Boston had promised the pecuniary means; but, under the enthusiastic support of Mr. Sarmiento, at first as Argentine Minister to this country, and later as president of that republic, it rapidly broadened, and finally led to the establishment by Dr. Gould of a permanent National Observatory at Cordoba. This marks an epoch in modern astronomy, the equalization of our knowledge of the two celestial hemispheres. The institution and its work form an impressive monument to his memory.

It is impossible, in brief space, to describe or characterize the marvelous work here undertaken and so faultlessly pushed to completion by Dr. Gould, during the fifteen years of self-imposed exile from his native land, with unfaltering devotion and energy, in the face of difficulty and domestic bereavement. The work on the uranography of the southern heavens was finished in 1874, and was published under the title of the *Uranometria Argentina*, which will remain a classic for all time. The zone-observations, of the stars between 23° and 80° south declination, which were the original and always the dominant object of the enterprise, were begun in 1872, substantially completed in 1877, and revised in 1882-83. This work was embodied in the Zone-Catalogues containing 73,160 stars, which appeared in 1884. Parallel with this, and almost overshadowing it in importance, was carried on the independent series of meridian circle observations for the General Catalogue of 32,448 stars, completed in 1885. Dr. Gould, besides, left the manuscript of the remainder of his series of fifteen volumes, not then published—containing the observations and the annual catalogues, incorporated in the General Catalogue—complete to the minutest detail, ready for the printer. These have since appeared from time to time—the last volume, rounding out his work, reaching Cambridge but a few hours before his death.

Another part of the work for the Cordoba Observatory, planned by Dr. Gould as a fitting extension of it, was a *Durchmusterung* of the southern sky. For this, indeed, he had provided the instrumental means and trained the assistants, it being his purpose to be ready to begin it at any time in case of any unforeseen delay or accident to the other work. On leaving Cordoba he confided it to the care of Dr. Thome and Mr. Tucker, who have since so worthily conducted it.

Dr. Gould also established, under the auspices of the Argentine

government, a meteorological service, second in extent, it is believed, only to that of the United States. Upon leaving South America he intrusted this charge to the hands of his worthy successor, Walter G. Davis.

The earliest to recognize and demonstrate the capabilities of photography to render service to astronomy of precision, Dr. Gould, by his experience with the Rutherfurd plates of the Pleiades and the Praesepe, was incited to arrange to carry forward at Cordoba, on an extensive scale, a similar work upon the southern stellar clusters. His other labors there were so onerous that he confined his attention to securing plates suitable for precise measurement. Of these he accumulated about 1400, and brought them home with him for measurement and reduction. Without permitting himself a well-earned retirement, he turned at once, tirelessly, to this labor, which has been the principal occupation of the last ten years of his life. This is substantially complete and will be given to the world as it came from his hand.

Dr. Gould had an enthusiasm for the advancement of his beloved science far wider than the limits of what he could by personal investigation accomplish. Early in his career he keenly realized that astronomy had reached a stage of development in America which entitled it to a higher claim than had yet been accorded to it; and that a journal worthily supporting the dignity of a pure science would have very great influence upon its future progress. Accordingly, without ostentation, he established the *Astronomical Journal* in November, 1849, offering it to the use of astronomers, for the publication exclusively of original investigations. He edited and supported it until, at the end of the sixth volume in 1861, its issue was suspended, first by the war for the preservation of the Union, afterward by his absence in Cordoba. A long nurtured hope was realized when he was enabled, in 1885, to resume its publication, and to continue it, at the rate of nearly one volume annually, to the present time. Of all the great enterprises of his life, this is the one which he has most cherished. With careful forethought, he has made due provision for its continuance.

Dr. Gould was born in Boston, September 27, 1824. He entered the Boston Latin school in 1836, and graduated from Harvard College, with high distinction in classical, as well as in mathematical and physical studies, in 1844.

He married, in 1861, Mary Apthorp Quincy, daughter of the Hon. Josiah Quincy. She died in 1883. Her sympathy with and

influence upon his life-work may be most reverently spoken of by recalling the lines of his dedication of the Zone-Catalogue:

"This Catalogue of Southern Stars, the fruit of nearly thirteen years of assiduous toil, is dedicated to the beloved and honored memory of Mary Apthorp Quincy Gould, to whose approval and unselfish encouragement the original undertaking was due, by whose sympathy, self-sacrifice, and practical assistance its execution was made possible, who bravely endured privation, exile and afflictive bereavement that it might be worthily finished, but who has not seen its completion."

Dr. Gould received the degree of Ph. D. from Göttingen, in 1848, and that of LL. D. from Harvard in 1885, and from Columbia in 1887. During his illustrious career he was the recipient of the highest honors that Europe has to bestow, to an extent scarcely vouchsafed to any other American. A few only will be named here. Mem. Roy. Soc. (London): For. Assoc. Roy. Astr. Soc. (London): Cor. Mem. Acad. Sci. (Institut de France): Acad. Imp. Sci. (St. Petersburg): Kön. Akad. Wiss. (Berlin): Kön. Ges. Wiss. (Göttingen): Kais. Akad. Wiss. (Vienna): Bur. d. Long. (Paris). He was also knighted, of the Order Pour le Merite, by the German Empire—a distinction shared, among Americans, only with George Bancroft and William Dwight Whitney, and which is extremely rare even in Europe.

THE ORBIT OF τ OPHIUCHI.

S. W. BURNHAM

For Popular Astronomy

This double star was discovered by Sir William Herschel April 28, 1873, and was described by him at that time as the closest of all his double stars. It appears as No. 88 of his Class I, the whole number of his discoveries in that class being 97. It was seen with so much difficulty with his 6.3-inch Newtonian reflector that he was at first inclined to question the reality of the suspected elongation. In his observation of this date he describes the appearance of the star:

"The closest of all my double stars can only be suspected with 460, but 932 confirms it to be a double star. It is wedged-formed with 460; with 932 one-half of the small star, if not three-quarters, seem to be behind the large star. The morning is so fine that I can hardly doubt the reality; but according to cus-

tom I shall put it down as a phenomenon that may be a deception."

Some years later, in 1802, he estimated the smaller component to be north of the principal star, or in a position-angle of 360°, and again in 1804 he noted it in the same angle. It appears to have received no further attention from astronomers until Struve examined it on three nights in 1825 and found it apparently single. In 1827 on one night he found it elongated in about 326° or 146°; but this appears to have been regarded as somewhat uncertain, and as partly due to refraction. In 1835 he measured it on six nights, and obtained very fairly accordant results in the values of the angle, the distance being estimated as 0″.35. In 1836 he made complete measures on five nights, and on one night in 1837.

These results are:

1835.68	$P = 192\ 9$	$D = 0.35$	$6n$
1836.62	199.9	0.43	$5n$
1837.70	200.8	0.35	$1n$

It soon became comparatively easy to measure by reason of the increased distance, and since that time the measures are numerous by most of the leading double star observers.

Five orbits of this system have been computed by eminent astronomers in the last fifty years. The periods found, and the dates of the last measures used in the respective orbits are as follows:

1846	Madler	87.03 years	Fixstern-System 1.253
1848	Hind	104. "	Mon. Not. IX, 145
1870	Doberck	185.2 "	A. N. 2037
1871	Doberck	217.87 "	Trans. R. I. Acad. XXV.
1895	See	230.00 "	A. J. 378.

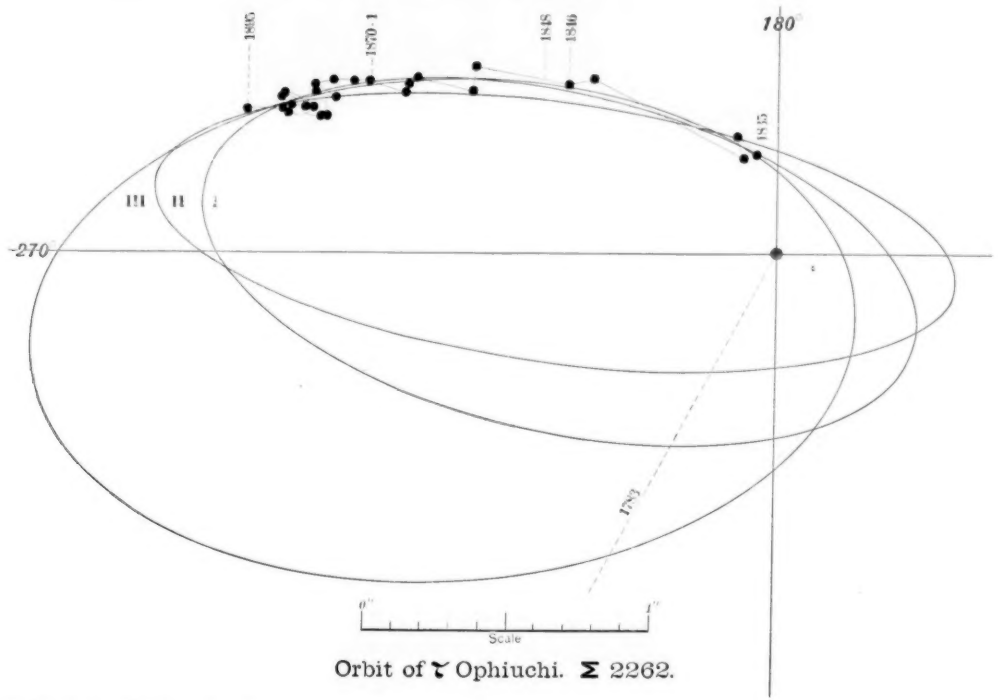
In the accompanying diagram I have given only the measures by the early observers whose observations cover a considerable period of time. Altogether twenty-six positions are shown by the following observers:

1835 to 1837	Struve	3
1841 to 1853	O. Struve	3
1858 to 1878	Dembowski	8
1880 to 1888	Hall	9
1892	Comstock	1
1893	Maw	1
1895	Collins & See	1

Each of these positions is the result of measures on from three to thirteen nights, and is therefore, presumably entitled to the highest value to be attained by the observer.

In attempting to find the apparent orbit of this system I have

PLATE XXXIX.



Orbit of ϒ Ophiuchi. Σ 2262.

considered it essential that it must represent with very little error the mean of the three Struve positions, which depend upon seven nights' measures. It must be assumed, I think, that this experienced observer from so many observations would determine the position-angle and distance with substantial accuracy, and I have, therefore, made this the initial point of departure for any ellipse which will satisfy the subsequent measures. It is evident that the form of ellipse should not be materially influenced by the very uncertain estimates of the angle by Herschel in 1802 and 1804 when the distance had certainly diminished, and by Struve in 1827, when the elongation was very doubtful. Doberck in his second orbit allows an error of 16°.9 in Struve's angle of 1835, and gives the computed distance as 0″.68 which is nearly double the observed distance; and in the position of 1836 the error is almost as large in both the angle and distance. It seems to me such a variation is not allowable in the work of any first-class observer, and especially in the matter of distance. No experienced double star observer could make so large an error in mere eye estimations, without using the micrometer at all; and it is certain from the observations themselves, and the notes accompanying them, taken in connection with the measures of Struve of close pairs of this class, that the distance in 1835-7 must have been sensibly less than 0″.5.

From the periods found heretofore, it is evident that each computer has assumed that about the maximum distance of the components had been reached at that time, and therefore, adopted the minimum ellipse which would satisfy the observations used. The distance has continued to increase since 1846, when Madler found a period of only 87 years with a nearly circular orbit, and consequently each succeeding computer has lengthened the periodic time. For anything which now appears, the distance may continue to increase for a long time to come.

There is no difficulty whatever in making any ellipse which would be adopted to represent the complete measures of 1835 to 1895, satisfy equally well the angle of Herschel in 1783. We know nothing of the distance at this time beyond Herschel's description of it as seen in his reflecting telescope. With a modern refractor of that aperture, one could safely assume from such a description that the distance between the components could not exceed 0″.4; but this distance would be far beyond the reach of any telescope ever used by Herschel so far as one can judge from all his discoveries of double stars. Careful examination of the other stars discovered by him, before and after this

time, and placed in his class I, in the light of the subsequent history of these stars, shows that very few, if any, of his stars at the time of discovery were less than 1″ in distance, and that many of them were much wider.

Three ellipses are shown on the diagram which represent equally well, and with substantial exactness, the angle of Herschel in 1783, and the measures by Struve and subsequent observers. So far as these observations are concerned, there is little to choose between them.

ORBIT I. This ellipse gives a correction of — 1°.9 to Herschel's angle, the distance at that time being 0″.78, and the position angle in 1803, 13°.2. The resulting period is 273.6 years.

ORBIT II. In accordance with this orbit, Herschel's angle was 2°.1 too large, and the distance at that epoch 0″.48. Struve's approximate observation of 1827 is also well represented by a position-angle of 132°.2. This ellipse gives a period of 264.9 years.

ORBIT III. For this ellipse we find a correction of 1°.5 in the angle of Herschel, and a distance of 1″.22 in 1783. The position-angle in 1803 is 346°.3, which is in fair agreement with the estimate made at that time. This ellipse gives a period of 466.9 years.

It is clear from inspection of these orbits, although they are very unlike in many respects, that so far as representing the principal observations is concerned, one is as probable as the other. With regard to the distance at the time of discovery, it is not probable under the circumstances that the components were separated by so small a distance as 0″.48, and in that respect perhaps either of the other ellipses is preferable.

It is apparent that at no time in the past has there been data sufficient to even guess at the form of apparent orbit, or the time of revolution. A much larger arc must be described by the companion to justify any attempt to determine the elements of this system. It must be remembered that there is probably a large error in the single measure made under the circumstances described by Herschel. If the error were as small as that found by either of these ellipses, it would be an accident which one cannot assume in making such an investigation; and with the latitude afforded by this uncertainty, it is obvious that an endless variety of ellipses could be found, any one of which standing alone, might be accepted by some as satisfying the requirements, and therefore as a valuable contribution to the knowledge of the system. The difficulty is further increased by the uncertainty as

to the maximum distance of the components. For anything that appears from the measures, these stars may continue to separate for a long period to come. It seems probable that the companion must be well into the fourth quadrant before any definite results can be found. As I have repeatedly pointed out before, it is not enough that the apparent ellipse represents the measures with all desirable precision, but it must be the only ellipse which will do it. Doubtless the early orbits of this pair represented the observations in a way satisfactory to the computer; and yet it is certain at this time that the period cannot be less than 200 years, and may be very much longer than any time thus far suggested.

BIOGRAPHICAL SKETCH OF WILLIAM CRAWFORD WINLOCK.

S. P. LANGLEY.

William Crawford Winlock, son of Joseph Winlock, formerly the Director of Harvard College Observatory, was born in Cambridge, Massachusetts, on March 27, 1859 and died at Bay Head, New Jersey, September 20, 1896.

His early years were passed in the Observatory at Cambridge, where his childish thought doubtless received a direction to the studies in which he had an almost inherited interest.

In 1874 he served in the United States Coast Survey in making observations for determining the force of gravity in the Hoosac Tunnel and was graduated from Harvard College in 1880 with a degree of A. B. During the latter part of his college course he was employed as aid in the Harvard Observatory, and received a temporary appointment as assistant astronomer in the United States Naval Observatory at Washington in August, 1880, which appointment was made permanent before the close of the year. He was detailed as an assistant to Professor Eastman, working on the equatorial and transit circle to 1883, but on the latter subsequently until the close of his connection with the Observatory in 1889.

He was employed during his entire service at the Observatory as an observer and computer in connection with the transit circle work, and made special observations on comets and asteroids with the equatorial, making most of the observations on the great comets of 1882, for which he prepared the Memoir of 1883.

On May 14, 1889, he accepted the position of Curator of International Exchanges and Honorary Curator of Apparatus in the Smithsonian Institution. The first of these positions brought him into relationships by correspondence with scientific men abroad, and while holding it, his continued interest in his profession led him to the preparation of much valuable astronomical bibliography for the publications of the Institution, being reports on the Progress of Astronomy covering the years for 1885 to 1892 which appeared in six separate memoirs. He also prepared briefer bibliographical articles for the *Sidereal Messenger*.

Of his services in the Bureau of Exchanges, Professor Edward S. Holden recently stated that to him "every scientific establishment in the wide world owes a debt of gratitude for his care of its interests."

Mr. Winlock at one time edited the astronomical column in *Science*, and, chiefly during his connection with the Institution, wrote articles on astronomical subjects which appeared in the *Astronomische Nachrichten*, in the Smithsonian publications and in the Proceedings of the American Academy of Arts and Sciences. He was Professor of Astronomy in Columbian University, and was at the same time engaged in writing articles on astronomy for Appleton's Encyclopedia, and on some of a more popular character for Harper's Weekly. One of his last works was the preparation of an article on comets for Lick Observatory.

The bibliography of Mr. Winlock's professional work is not complete and is far from adequately presented in this brief notice.

Mr. Winlock's habits of orderly method, acquired in part from his profession, stood him in admirable stead in his responsible position as Curator of Exchanges, to which was later added the responsiblities of the position of Assistant in Charge of Office, which made him, next to the Assistant Secretary, the trusted aid of the Secretary in all affairs of the Institution. In this capacity, to which he was appointed on October 1, 1891, he rendered invaluable service, and united with an efficient administration the regard of all who knew him. His was a gentle and refined nature, associated with endearing personal qualities, which made his loss as deeply felt by all of his subordinates as by those whom he in turn assisted.

In this place it is proper to speak chiefly of the work which he did directly connected with his profession, yet I cannot but add an expression of my own loss in one who had not only gained my fullest confidence, but who was a dear friend, whose place it seems can hardly be supplied.

CHRONOLOGICAL NOTES.—V.

R. W. MCFARLAND.

FOR POPULAR ASTRONOMY.

THE DAY, THE MONTH, THE YEAR.—ECLIPSES AND CHRONOLOGY.

The term Calendar month, *i. e.*, the month as given in almanacs, has been sufficiently set forth in a preceding article. *Month* as used in this article refers to the motion of the Moon around the Earth. The time required for the Moon to travel from one star back to the same star, was formerly called the *sidereal* month; the time required to make a revolution, so as to come back to the same position in reference to the Sun, is the *synodical* month, or *synodical revolution* of the Moon. The term *sidereal*, as applied to time now, does not refer to the stars, (*sidus* is Latin for star), but to the equinoctial point, the vernal equinox. The month from star to star is longer than the month from equinox to equinox by a small amount;—the equinox moving westward continually and meeting the Moon before it has traveled 360 degrees. This retrograde motion varies from 42 to 58 seconds a year. The calendar months vary from 28 to 31 days,—and the history of the case concerning this point was given some time ago. The *lunar* month, the *synodical* month, with which we are now concerned is always between 28 and 31, and is, on the average, about 29½ days.

In Young's Astronomy you find figures claiming great accuracy; but he says the time "varies somewhat." When the case is examined, as it will be presently, all readers of this article can heartily endorse the statement. The months all vary, all days vary, and all years, also. To be specific about it, I say that no two days of the year are *exactly* the same length; and no day is *exactly* 24 hours. No two months are *exactly* equal, and no month is ever of the length given in works on astronomy; and lastly, the years all differ from each other, and no one of them is of the same length as the *average* year. Besides no two independent writers on astronomy agree in regard to that average length.

The days do not differ greatly, nor do the years, but the months do; and I wish to bring these facts out so plainly that no mistake need be made by any one. It is not so stated here merely to make a point, or to seem unnecessarily exacting. The facts are rarely mentioned in treatises on astronomy, and conse-

quently they are either entirely unknown, or only partially apprehended,—at least, such is my opinion—and so I beg pardon for unnecessary particularity, if so it shall be judged.

The Earth's velocity in its orbit around the Sun varies. It is slowest at the aphelion, July 1, and most rapid at the perihelion January 1.

The Earth revolving on its axis uniformly—[there is no certain proof that it does not]—has to turn round a little over 360 degrees in order to bring the Sun to the meridian. And as the excess over 360 degrees varies every day, all the days will be of different lengths, but the average will be 24 hours. From January 1 to July 1, each succeeding day is a little shorter than the one before it. The excess over 24 hours at the first of January, is about 8 seconds; the deficit at the first of July is not quite so great. This unequal motion of the Earth in its orbit is one of the two causes which make the Sun and the clock differ in the hour of noon,—the clock being too fast or too slow, as the case may be.

The years also all differ from each other,—no two are alike and no one is of the length given by any writer on astronomy. Let us test the matter. Taking the American Nautical Almanac for 1885 I look for the declination of the Sun at noon on the day before the vernal equinox and also on the following day; *i. e.*, the two noons between which the equinox takes place. Then supposing the Earth's motion sensibly uniform for the 24 hours, as it is very nearly, we easily, by simple proportion, find the exact instant of the equinox for that year. Applying the like procedure through the successive years to and including 1894, we have the length of nine successive years. Here are the results:

The year ending at the March equinox was in

	d	h	m	s
1886	365	5	56	35.9
1887	"	"	52	11.7
1888	"	"	37	29.4
1889	"	"	53	51.5
1890	"	"	51	4.8
1891	"	"	43	3.4
1892	"	"	57	48.4
1893	"	"	46	5.4
1894	"	"	51	2.4

No one of these agrees with any year given in any work on astronomy. The average for these 9 years is $365d\ 5^h\ 49^m\ 54^s.7$. This, too, is a new number. The figures above show that 6 of the nine years are longer than "the law allows," so to say; and the average is more than a minute too long. Had I taken any

other period of 9 or 10 years, like results would have been found; but all would differ from these above given, and differ from each other. Try it for 1,000 years, like results will follow. No year would be found of the length given in the text-books. The longer the period, the more nearly the figures will approach the true average length of the year. But this *true average* is altogether *theoretical*, it is not obtained by observation. Let us see what the ablest astronomers make it. All agree in the days, hours, and minutes. The difference applies only to the seconds.

Le Verrier says	45.5 seconds.
Newcomb	46.0 "
Bessel	47.8 "
Gummere and others	48.0 "
Baily and Herschel	49.7 "

Bessel gives the fraction of the day as .24222. This reduced, gives the year 365*d* 5^h 48^m $47^s.8$ as above. Now who will say what the *exact length* is, even if there is such a thing? Furthermore, the years grow shorter continually, and have been so changing for many thousand years, and will so continue for many thousands to come. The diminution is about 6 tenths of a second in a century (see Chauvenet's Ast. Vol. 1, Art. 407). But this rate, too, changes with the "ever rolling years."

The average for the 9 years above given is about 1 minute and 7 seconds longer than Bessel's year—which is for 1800. For 1900 we reduce the seconds from 47.8 to 47.2. In view of the results of this discussion, would it not be well for writers on astronomy to give some hint of these facts? And not set down a hard and fast number, as if that were "the truth, the whole truth, and nothing but the truth." A sentence or two would be sufficient to put all readers on their guard.

If with all the mathematics, and all the telescopes, and all the "Celestial Mechanics" of modern times, men do not come to any very close agreement in this matter, it is but just that we credit the ancient Egyptians with right methods and fair results, when 20 centuries and more before Christ, they had made out the year to be 5^h 55^m over 365 days. They used only sticks and shadows, and the naked eye. From the preceding statements it appears that the difference between the longest day and the shortest one, is about one fourth of a minute; and the difference between the years may be more than 20 minutes.

Let us see how the month fares. Two consecutive months may differ by two or three hours; and sometimes the months of a single year may differ by 12 hours or more, and the months of dif-

ferent years by a still larger quantity. The time of *new Moon* is given in the Nautical Almanac for each lunation. Observers know well that the Moon generally varies a little on one side or the other of the computed place, but only by very minute quantities. The times for all the other phases of the Moon are also given in the Nautical Almanac. Almanac makers, as stated in a previous article, always copy directly from the Nautical Almanac, all the changes of the Moon, making due allowance, however, for the longitude of the place for which the almanac is made. The interval, therefore, between phases of the Moon will be the same, whether taken from the common or the Nautical Almanac:—supposing, of course, that no errors have been made. The common almanac usually gives the time to the nearest minute,—the Naut. Alm. to the nearest tenth of a minute.

The truth of the preceding general statement can be verified by any one. All that is required is to find the interval from one new Moon to the next, in any common almanac, or from 1st quarter to 1st quarter, &c., &c. No two of these intervals will be found equal. In this way I took the time from new Moon to new Moon, from an almanac computed for the longitude of Boston, $4^h\ 44^m$ west of Greenwich, (a suburb of London,) from the meridian of which place, English speaking people count their longitude and time.

Taking almanacs from 1890 to 1896, inclusive, we find as follows: the longest months were in

1890 . . .	29^d	15^h	34^m
1891 . . .	29	17	14
1892 . . .	29	18	55
1893 . . .	29	19	27
1894 . . .	29	18	38
1895 . . .	29	19	17
1896 . . .	29	18	36

The shortest months for the same years are as follows:

1890 . . .	29^d	10^h	33^m
1891 . . .	29	9	6
1892 . . .	29	7	3
1893 . . .	29	6	56
1894 . . .	29	6	39
1895 . . .	29	7	24
1896 . . .	29	8	35

The average length of the month is $29^d\ 12^h\ 37^m$ for the 7 years. The difference between the longest and shortest month is, for

1890 . . .	5^h	1^m
1891 . . .	8	8
1892 . . .	11	52
1893 . . .	12	31
1894 . . .	11	59
1895 . . .	11	53
1896 . . .	10	1

The greatest difference of any two months in these 7 years is $12^h\ 48^m$. If one should take any other 7 years, or any number whatever, he would find a like set of results. The greater number of years, the nearer the resulting average would be to the true synodical month. As before said, the time from 1st quarter to 1st quarter, or the time from full Moon to full Moon, &c., &c., will always differ from the time from new Moon to new Moon. Let us see what writers on astronomy say of this period, the synodical month.

The Ency. Brit., Brande, and Young give	29.53059 days.
Gummere,	29.5305885 days.
Sir John Herschel and Robinson,	29 530588715 days.
Loomis,	$29^d\ 12^h\ 44^m\ 2^s.87$

which is the same thing reduced to hours, minutes, and seconds.

The fraction so given is always the result of calculation—never of observation. The synodical revolution is given by Young as $29^d\ 12^h\ 44^m\ 2^s.684 \pm 0^s.01$. [I think this .684 is a misprint for .864, each of the preceding fractions gives .864 or a fraction slightly larger.] I might have said at the close of the tables above given, that the months do vary "somewhat" in their length,—perhaps a good deal more than most people suppose,—including astronomers.

Young further says that the synodical period is fixed "by comparing ancient and modern eclipses of the Sun. . . . . The earliest authentically recorded eclipse was one that was observed at Nineveh in the year 763 B. C. between 9 and 10 o'clock in the morning of June 15. Another occurred May 28, B. C. 585, about three o'clock in the afternoon, during a battle between the Medes and Persians."

[*Persians* here is a slip for *Lydians*. See Herodotus, B. I., who relates the story.]

And on statements like the above, given by astronomer after astronomer, men have been led to suppose that eclipses have fixed the dates of many historical events.

Let us look into this matter a little more closely. Young further says, "By comparing the earlier of these with (say) the eclipse of August, 1887, we have an interval of more than 35,000 months, and so an error of 10 hours even, in the observed time of the Nineveh eclipse, would make only about one second in the length of the month. Of course an error of a single hour is quite impossible, and by comparing the mean result derived from many such ancient eclipses with modern, the ultimate error in the length of the month is reduced to a very minute quantity."

We shall see about this. The number of months above given is more than 2,000 too great, but that cuts no figure in this discussion.

Sir John Herschel in his uniquely careful way of expressing himself, says, "Remarkable eclipses, for instance, now that the lunar theory is thoroughly understood, can be calculated back for several thousand years, without the possibility of mistaking the day of their occurrence. And, whenever any such eclipse is so interwoven with the account given by an ancient author of some historical event, as to indicate precisely the interval of time between the eclipse and the event, and at the same time completely to identify the eclipse, that date is recovered and fixed forever."

This is well said: it is a capital criterion: let us try how it works in the above case. (*I may say, in parenthesis, that no such identification has ever been made, or is ever likely to be.*) These are three points in the criterion:

1. A certain eclipse.
2. A definite historical event.
3. Complete identification of the two.

In all the cases which I have examined or read of, the above 3d point is altogether wanting; and the 2d, is in much the same condition, for want of dates in the old writers. I could elucidate the case by several examples, but the one above must suffice—it is the most celebrated of all. To refer to a part of a preceding quotation from Young,—"Another occurred on May 28, B. C. 585."

In regard to this eclipse, Whewell in his *History of the Inductive Sciences*, says [3d Ed. Vol. I, p. 508].

"'The Eclipse of Thales' is so remarkable a point in the history of astronomy, and has been the subject of so much discussion among astronomers, that it ought to be especially noticed. The original record is in the first Book of Herodotus's History (Chap. lxxiv)." Whewell then translates the passage from Herodotus, and extending his remarks, at length says, "Now that the theory of the Moon is brought so far towards completeness, astronomers are able to calculate backwards the eclipses of the Sun which have taken place in former times; and the question has been much discussed in what year this eclipse of Thales really occurred. The Memoir of Mr. Airy, The Astronomer Royal, on the subject, in the *Phil. Trans.* for 1853, [Vol. 143] gives an account of the modern examinations of this subject. . . . Mr. Airy concludes from his calculations that the eclipse predicted by Thales took place B. C. 585;"—May 28, as above given.

Airy was born in 1801, and was for 45 years Astronomer

Royal. He died only a few years ago [1892]. He was as competent as any man to fix such a date.

Sir Francis Baily (born 1774—died 1844)—the man who gave the British Nautical Almanac its present form substantially, as well as that of our own, which is modeled after the British, was a man as well qualified as any to do such work, and who calculated more eclipses than probably any other man—also tried the same eclipse. Speaking of this work, Sir John Herschel (Outlines of Ast. 4th Ed., p. 537) says, "See the remarkable calculations of Mr. Baily relative to the celebrated solar eclipse which put an end to the battle between the kings of Media and Lydia, B. C. 610, Sept. 30, *Phil. Trans*, ci, 220."

Here are two very able mathematicians and astronomers, having the same chapter of Herodotus before them, both men knowing also that the "Theory of the Moon" is all right, who come within 25 years of the same date for that eclipse. Comment is superfluous; pages of it would be useless. The crucial test fails completely. Let us hear Herschel again, . . . "And whenever any such eclipse is so interwoven with the account . . . of some historical event, as to indicate precisely the interval of time . . . at the same time completely to identify the eclipse, that date is recorded and fixed forever." This is plain as an axiom: the difficulty is to comply with the conditions. Does this eclipse determine the synodical revolution of the Moon, so as to make "the error a minute quantity?" "I trow not." If 10 hours would make a differeuce of a second, 25 years would make over 6 hours. The synodical revolution of the Moon is not determined by "New Light from Old Eclipses." I, too, desire information,—when did the eclipse of Thales occur? I might quote again, and say "I pause for a reply."

The difficulty is not in the "Theory of the Moon," it is in the vagueness of the historical account. If the printers of this Journal were well prepared for printing Greek, I should like to quote the whole passage from Herodotus in the original. Herodotus did not trouble himself about dates. He had stories to tell, and he told them in a style at once inimitably simple and beautiful.

This investigation may serve to emphasize a remark made in a former article to this effect, *that it is absolutely impossible to fix definitely any date before the reformation of the Calendar by Julius Caesar*, and that even in dates for a long period subsequent to that reformation, there is always an overhanging cloud of doubt.

NOTE.—In my article in the November No. of this Journal, I

meant to give the first sentence in Macaulay's History of England, but being far from my library, I depended on memory, and so wrote "William and Mary," instead of "King James the Second." R. W. M.

MERCURY.

PERCIVAL LOWELL.

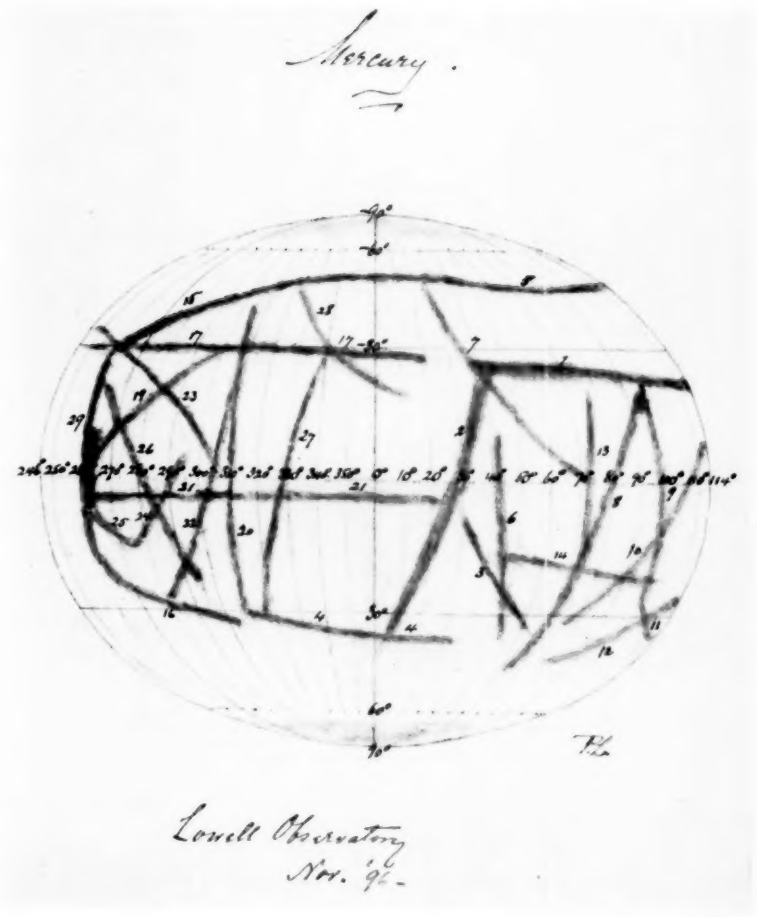
FOR POPULAR ASTRONOMY.

Conditions of Observation.—The following observations were all daylight ones. They were made before, at and after noon, and on both sides of the Sun with the planet as a rule from an hour and a half to five hours past the meridian and with a declination of from 0° to 14° south. The atmosphere proved much better than I had anticipated, giving at times very good images. The eye-piece found to be the best was one which on the 24-inch glass magnified about 140 diameters. The next higher one at hand, one of three hundred diameters was also good. Higher powers than this are impracticable. I mention this because a great deal of misconception exists with regard to the powers possible in planetary work. From my own experience and that of my assistant Mr. Drew, I judge that on a glass of this size in this atmosphere the ideal eyepiece would be one of a little over 1½ inches focal length, magnifying about 225 times—they are long and rather narrow, almost invariably.

Markings.—The markings on the planet's disk proved at once to be conspicuous. They are nearly as dark as the markings on Mars and much darker than those on Venus. In good air they were very easy and perfectly defined. So visible were they at all times,—for the air had to be distinctly bad to obliterate them—that observations had not been made more than a day or two, before the rotation period of the planet was patent.

Albedo.—At the time the observations began the planet was between superior conjunction and eastern elongation and lay at the time very conveniently placed for comparison with Venus, the two planets being near one another, Mercury lying at first at a somewhat greater angular distance from the Sun and then at a slightly less, Venus passing out and Mercury in on Sept. 24th. The difference in the albedo or intrinsic brightness of the surface

PLATE XXXII.



Index to Map of Mercury.

1	Maiæ regio	11	Serpentis regio	21	Oneiropompi regio
2	Parameses regio	12	Anguis regio	22	Hyphates
3	Cyllenes regio	13	Paranetes regio	23	Plectri regio
4	Mercatorum regio	14	Chelydoreæ regio	24	Alæ regio
5	Petasi regio	15	Testudinis regio	25	Talarium regio
6	Trites regio	16	Lyræ regio	26	Sarameias regio
7	Pteri regio	17	Psychopompi regio	27	Lichani regio
8	Netes regio	18	Laræ regio	28	Somnii regio
9	Caducei regio	19	Oneiraton regio	29	Argi regio
10	Fili regio	20	Parhypates regio		

meant to give the first sentence in Macaulay's History of England, but being far from my library, I depended on memory, and so wrote "William and Mary," instead of "King James the Second." R. W. M.

MERCURY.

PERCIVAL LOWELL.

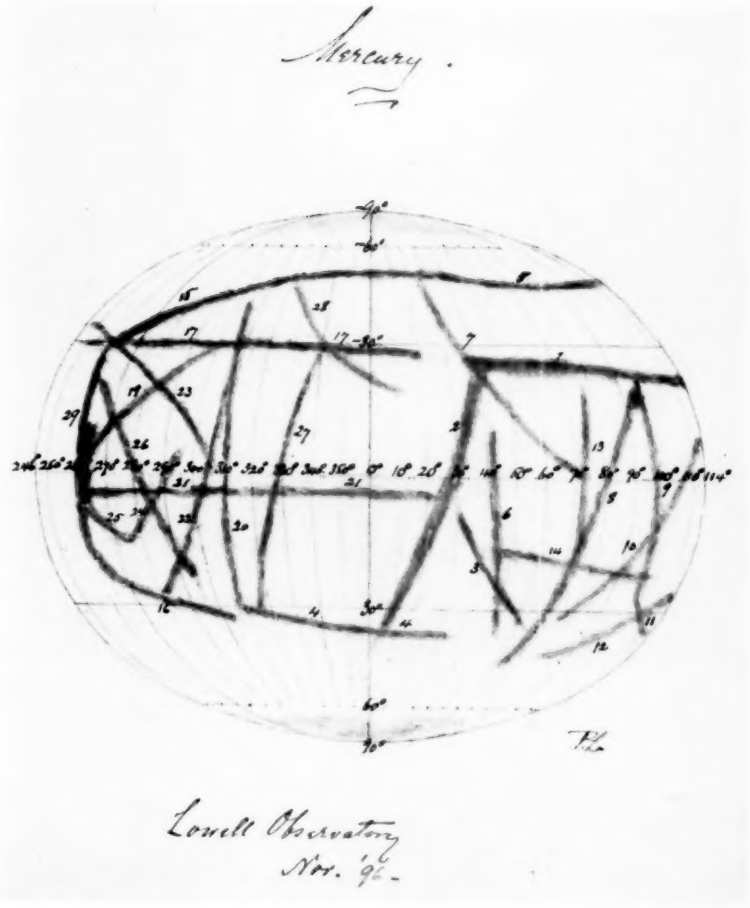
FOR POPULAR ASTRONOMY.

Conditions of Observation.—The following observations were all daylight ones. They were made before, at and after noon, and on both sides of the Sun with the planet as a rule from an hour and a half to five hours past the meridian and with a declination of from 0° to 14° south. The atmosphere proved much better than I had anticipated, giving at times very good images. The eye-piece found to be the best was one which on the 24-inch glass magnified about 140 diameters. The next higher one at hand, one of three hundred diameters was also good. Higher powers than this are impracticable. I mention this because a great deal of misconception exists with regard to the powers possible in planetary work. From my own experience and that of my assistant Mr. Drew, I judge that on a glass of this size in this atmosphere the ideal eyepiece would be one of a little over 1½ inches focal length, magnifying about 225 times—they are long and rather narrow, almost invariably.

Markings.—The markings on the planet's disk proved at once to be conspicuous. They are nearly as dark as the markings on Mars and much darker than those on Venus. In good air they were very easy and perfectly defined. So visible were they at all times,—for the air had to be distinctly bad to obliterate them—that observations had not been made more than a day or two, before the rotation period of the planet was patent.

Albedo.—At the time the observations began the planet was between superior conjunction and eastern elongation and lay at the time very conveniently placed for comparison with Venus, the two planets being near one another, Mercury lying at first at a somewhat greater angular distance from the Sun and then at a slightly less, Venus passing out and Mercury in on Sept. 24th. The difference in the albedo or intrinsic brightness of the surface

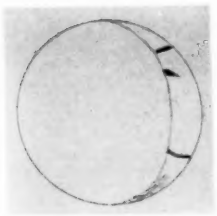
PLATE XXXII.



Index to Map of Mercury.

1	Maiæ regio	11	Serpentis regio	21	Oneiropompi regio
2	Parameses regio	12	Anguis regio	22	Hyphates
3	Cyllenes regio	13	Paranetes regio	23	Plectri regio
4	Mercatorum regio	14	Chelydoreæ regio	24	Alæ regio
5	Petasi regio	15	Testudinis regio	25	Talarium regio
6	Trites regio	16	Lyræ regio	26	Sarameias regio
7	Pteri regio	17	Psychopompi regio	27	Lichani regio
8	Netes regio	18	Laræ regio	28	Somnii regio
9	Caducei regio	19	Oneiraton regio	29	Argi regio
10	Fili regio	20	Parhypates regio		

PLATE *Mercury.* XXXIII.

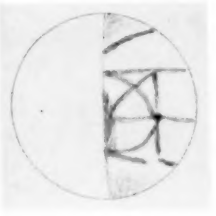


Oct 16. $2^h\ 13^m$ to $4^h\ 19^m$
$\lambda = 237°$

Oct 17 $23^h\ 38^m$ to $4^h\ 48^m$
$\lambda = 247°$

Oct 19 $3^h\ 6^m$ to $5^h\ 12^m$
$\lambda = 257°$

Oct 19 $23^h\ 45^m$
$\lambda = 254°$



Oct. 24. $23^h\ 98^m$
to Oct 25. $0^h\ 4^m$
$\lambda = 269°$

Oct 27 $22^h\ 47^m$ to $5^h\ 59^m$
$\lambda = 277°$

Oct. 27. $23^h\ 35^m$ to $4^h\ 46^m$
$\lambda = 277°$

Oct. 28. $2^h\ 53^m$
$\lambda = 277°$

Oct 28. $22^h\ 25^m$ to $5^h\ 57^m$
$\lambda = 280°$

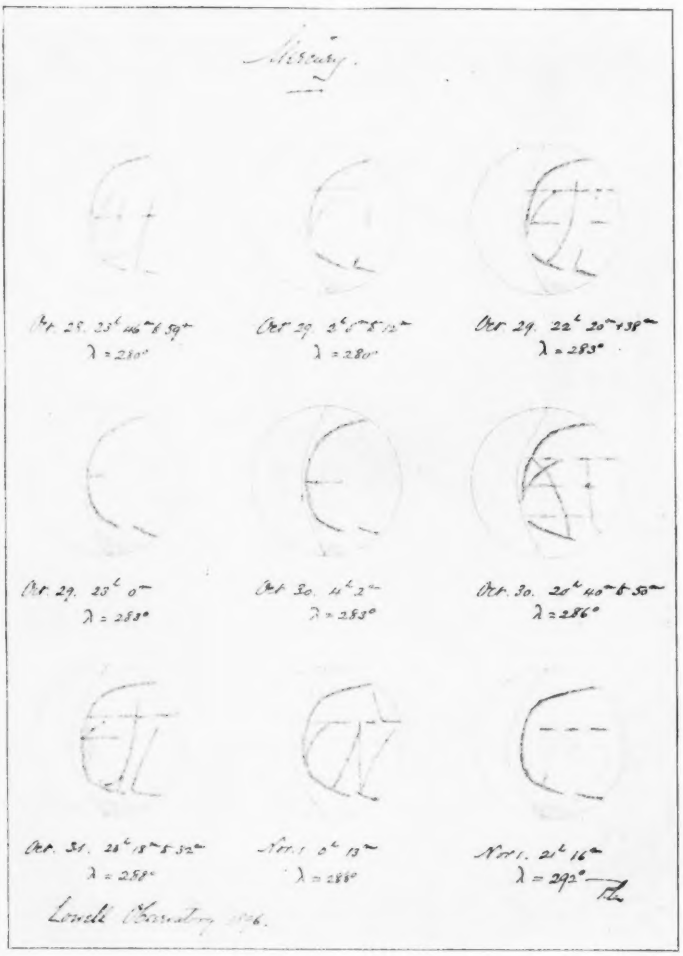
Lowell Observatory 1896.

P.L.

PLATE XXXIV.

Drawings.
Oct 17. 2h 35m
λ=242°
Oct 19. 3h
λ=251°
Oct 19. 23h 50m
λ=254°
Oct 23. 23h 19m
λ=266°
Oct 27. 23h 50m
λ=277°
Oct 28. 2h 58m
λ=279°
Lowell Observatory
1896.
Oct 28. 23h 15m
λ=280°
Oct 28. 23h
λ=280°
Drawings by
E. E. Barnard

PLATE XXXV.


Mercury.
Oct. 28. 23h 46m 6.59s
λ = 280°
Oct. 29. 2h 8m 8.12s
λ = 280°
Oct. 29. 22h 20m 4.38s
λ = 283°
Oct. 29. 23h 0m
λ = 283°
Oct. 30. 4h 2m
λ = 283°
Oct. 30. 20h 40m 6.50s
λ = 286°
Oct. 31. 20h 18m 5.32s
λ = 288°
Nov. 1. 0h 13m
λ = 288°
Nov. 1. 21h 16m
λ = 292°
Lowell Observatory 1906.

of the two bodies was most marked. The initial note made on Mercury, on Aug. 21st, was: "Mercury—strikingly not so bright in albedo as Venus just looked at in a brighter sky, too." At this time Mercury was nearer the Sun in the proportion of 100 to 165 and therefore his surface was 2.7 times more brilliantly illuminated than hers. But the relative lustre of the two was even more disproportionate the other way. This relative appearance continued to be presented on every occasion; only with ever increasing contrast. For as Mercury's phase increased, his surface lost visibly in lustre; that is, quite apart from the loss in area as a whole, what illuminated surface remained showed much less bright, square unit for square unit, than it had when the disk was nearer the full. A similar loss of albedo with increase of phase is shown by our Moon.

Mountainous Character of Surface.—The loss of brilliancy in both Mercury and the Moon is what would follow from a rough, *i. e.*, mountainous surface seen by an outsider under different angles of illumination. We may therefore conclude, since Mercury is largely devoid of encompassing atmosphere,—as is evident from observations here—that his surface is very likely in large part mountainous or craterful.

Absence of Atmosphere.—That they are seen at all times with perfect distinctness goes to prove that they are not veiled by an appreciable atmosphere. All the other phenomena shown by the planet support this conclusion. When Mercury passed across the Sun's face on Nov. 10th, 1894 he was watched at this Observatory and throughout his transit showed no signs of any atmospheric envelop. This absence of atmosphere is in keeping with what general principles would lead us to expect from the kinetic theory of gases.

Absence of Water.—As the planet has next to no atmosphere he can have practically no oceans nor seas.

Character of the Surface.—The look of the surface carries out this conclusion. The low albedo of the disk, considered in connection with the distinctness of the surface markings shows that we are here in all probability viewing weathered rock and soil much as on the Moon.

The absence of color on the disk, which is marked, supports the same inference. Unlike Mars the surface shows only differing tints of gray, there being no color worthy the name to be seen anywhere.

From the drawings of the planet's surface markings it is at once evident that the rotation period of the planet is synchronous with its orbital period. I have selected for reproduction with this article those made from October 16 to November 8. Besides revealing the rotation period they show a detail connected with it of some interest, the effect of the planet's libration.

Position of Axis.—The drawings also demonstrate that the planet's axis is substantially perpendicular to the plane of its orbit, since otherwise the markings would apparently swing about some temporarily fixed point on the disk.

Libration.—In the case of a planet revolving in a circular orbit around the Sun and rotating on an axis perpendicular to the plane of that orbit once in the course of the a revolution, the effect would be a turning by the planet of the same side perpetually to the Sun and a consequent perpetual illumination of the same hemisphere. If, however, the orbit were not circular but elliptic, the other conditions remaining the same, there would result a libration in longitude which would reveal, first on one side and then on the other, further portions of the disk. The amount so revealed would depend upon the eccentricity of the orbit. Now while the orbit of Venus is almost circular that of Mercury is for a planetary orbit highly eccentric. In consequence although in the case of Venus the libration in longitude due to the eccentricity of the orbit amounts to only 47′ on either side of the mean position, in the case of Mercury it amounts to 23° 39′.

In the case of Venus, therefore, the effect of the libration is practically imperceptible; as a swing of the markings of 47′ or of about three-quarters of a degree one way or the other from the mean can hardly permit of detection with our present optical appliances at the distance we are away from her. Not so with Mercury. In his case the libration amounting to 23° 39′ on either side of the mean, is not only a perceptible but a very noticeable quantity indeed. So large in fact that in consequence of it we see at one time and another instead of but one-half of his surface, actually five-eights of it, only three-eights of it remaining forever hidden.

Now it so chances that the markings on one side of Mercury are such as to render this libration instantly and very strikingly evident to terrestrial observers. When the planet is morning star and in its mean rotational position there may be seen on the east-

PLATE XXXVI.

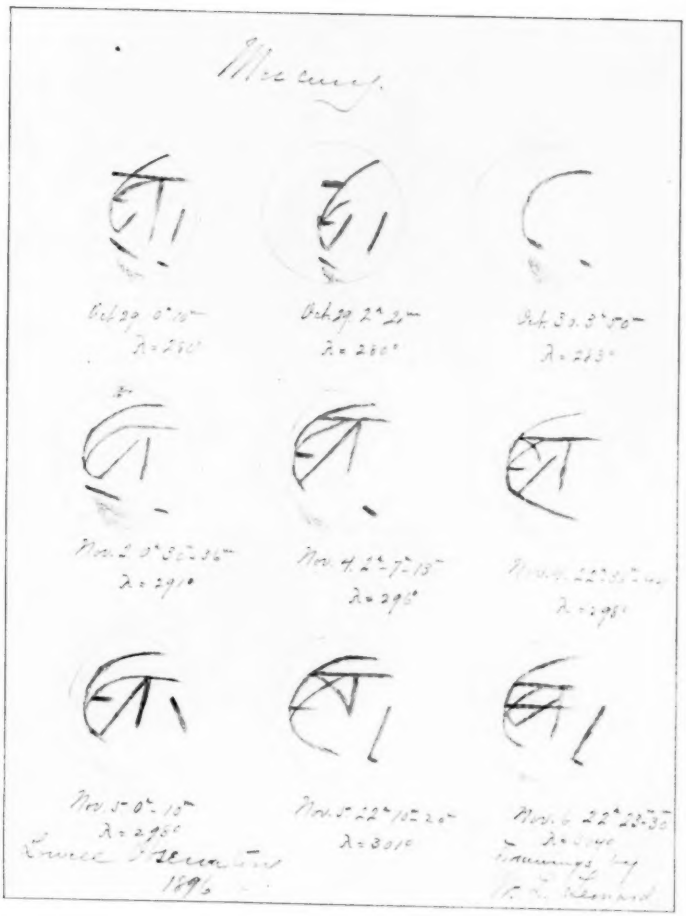

Mercury.
Oct. 29 0h 15m
λ = 270°
Oct. 29 2h 21m
λ = 280°
Oct. 30 3h 30m
λ = 293°
Nov. 2 0h 0m 30m
λ = 291°
Nov. 4 2h 7m 15m
λ = 295°
Nov. 5 0h 15m
λ = 298°
Nov. 5 22h 15m 20m
λ = 301°
Nov. 6 22h 23m 30s
λ = 306°

PLATE XXXVII.

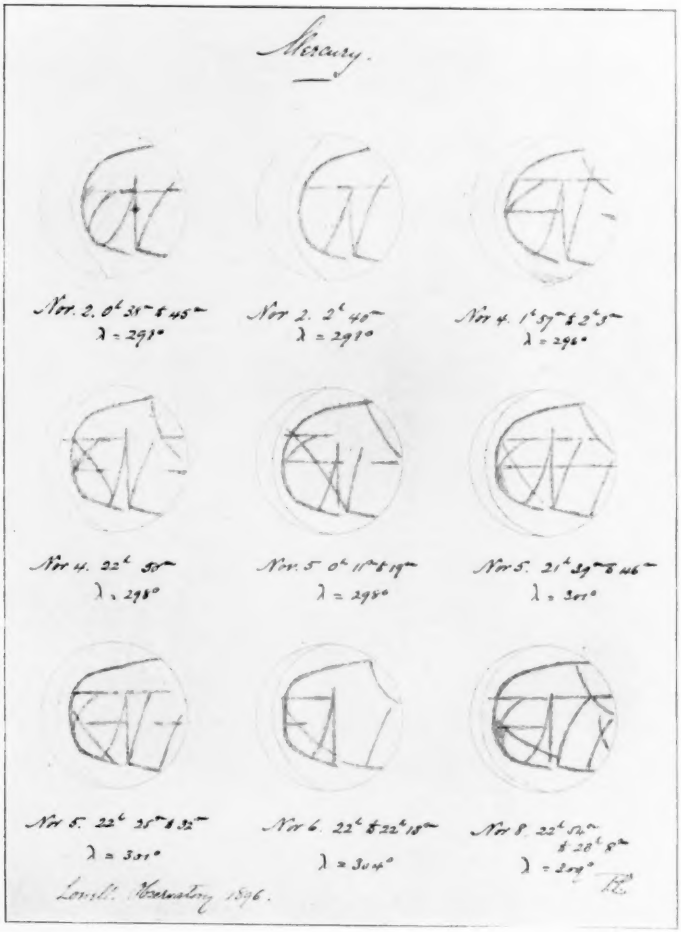


PLATE XXXVIII.

Nov. 6 22ʰ 52ᵐ ♃ 23ʰ 4ᵐ
λ = 304°

Nov. 8 22ʰ 46ᵐ 52ˢ
λ = 309°

Nov. 8. 23ʰ 10ᵐ 15ˢ
λ = 310°

Lowell Observatory
1896.

Drawings by
P. A. Lemaire

ern side of the disk,—what would be the eastern, that is, to me standing on the planet,—two line like markings that belt the north and south poles respectively not far distant from them and slanting somewhat equatorwards to the east. So noticeable are these lines that when the planet is crescent they have the effect of cutting off both horns. For they run from the limb plumb to the terminator. They are at this time the most evident markings on the disk. Their extremities on the terminator are far distant from one another and no one would so much as suspect that the two had any possible connection.

As the libration begins to swing the illumination across the disk eastward the two lines appear to bend a trifle more toward each other at their terminator ends. As the libration advances the lines incline still more until all at once when the surface exposed by the swing amounts to about 20° the two are seen to be joined all the way down the disk close along the eastern edge, forming one continuous band. With the increasing libration the fringe of light between this and the terminator widens until at the maximum the band lies well on the disk, and has the look of a horizontal horse shoe whose extremities almost cut off the poles. As the marking is throughout the most salient one on the planet the effect is striking.

There could hardly be imagined a more conspicuous proof of the synchronous character of the rotation and orbital periods than this, its theoretical corrollary made visible. Just where theory predicts a deviation from an invariable illuminated half is the variation to be seen. It is very singular—unless there be a cause for it in its very position—that there should happen to be a line placed there to show.

LOWELL OBSERVATORY, Dec. 3, 1896.

THE TEACHING OF DESCRIPTIVE ASTRONOMY.

HERBERT A. HOWE.

FOR POPULAR ASTRONOMY.

At the request of the editor of POPULAR ASTRONOMY the writer contributes further hints on the teaching of descriptive astronomy, in continuation and expansion of those given in November.

It will be observed that the purpose is to reduce mere memorizing to a minimum, and to require a reasonable maximum of observation. The principle is that it is always better, when circumstances will permit, to require a student to think out a given conclusion, by answering judicious questions, than to tell it to him. Were a solid six months, or longer, at the disposal of the teacher, the "laboratory method" could be used almost exclusively, with great profit, when the teacher's guidance is firm and intelligent, but there are very few schools in the country where such a length of time is available.

I. *Memorized Work.*—What is the minimum of memorized work with which the scholar should come to his final examination? He should know the distances, diameters, times of revolution, and times of rotation of the planets, and of the Moon, together with the number of known satellites of each planet. He should be able to give a description of the appearance of each planet in a powerful telescope, and of their physical constitutions, so far as known, or reasonably surmised. His knowledge of the main appearances seen on the Sun and Moon should be pretty accurate. The student should be able to give good explanations of the main facts about the constitution of comets, their changes of appearance and their orbits. The principal facts about meteoric showers, stars, multiple and variable, and nebulæ should be well known.

II. *Mathematical Work.*—How much of the mathematics of the subject may profitably be introduced into an elementary treatment, such as is given in the last year of a High school course, or in a descriptive course in college? The writer is accustomed to restrict such work chiefly to what is necessary for an understanding of the different kinds of time, and their determination in an observatory or at sea, combining with this the seasons and the calendar. A very rudimentary treatment of the subjects of precession, aberration, parallax and refraction is also given.

After the students, by means of their observations and by a course of questions, have become pretty familiar with the apparent daily motion of the celestial sphere, and the positions of the north celestial pole and equator upon it, the systems of spherical coördinates are taken up, beginning with the latitude and longitude of cities on the Earth. The only circles considered in this system are the fundamental one (the equator) and the secondaries (the meridians), parallels of latitude being discarded. The only points of reference are the poles, and what is denominated the fundamental point on the equator, viz., the intersection of

the prime meridian with the equator. The horizon system is then developed, the horizon being the fundamental circle, the vertical circles being secondaries intersecting in the zenith and nadir, and the fundamental point being the south point of the horizon: the coördinates are of course altitude and azimuth. On some accounts it is advisable to include the zenith distance.

The celestial equator system of right ascension and declination is similarly worked out, the scholars being urged to make a mental picture of the hour circles and celestial equator drawn as silver lines on the celestial vault above their heads. The vernal equinox and the stars are thought of as silver nails on the sphere, which rotates daily upon an axis drawn from the north celestial pole to the observer, carrying with it the system of hour circles and the stars.

In order to understand sidereal time and hour angle the horizon system is mentally pictured as a set of golden circles which appear to us to be fixed in position, and not to be fastened upon the celestial sphere, as were the silver circles, but rather to stand independently just inside of the concave of the celestial vault, so that the silver circles and stars may sweep past the gold circles unimpeded.

To help the conception of the relation between sidereal time and right ascension the silver hour circles are thought of as 24 in number, and at the foot of each, where it cuts the equator, is a huge figure, 0, 1, 2, 3, etc., from the vernal equinox eastward. The student sees (in imagination) these huge figures sweep past the golden circle which represents his local meridian, as the sphere turns, and also sees the hour hand of a sidereal clock keeping pace with them. Then he readily grasps the relation between the sidereal time at any instant, the right ascension of any star, and its hour angle at the instant.

All this is very puerile, in the eyes of an astronomer, but is satisfactory to a student.

The student is now prepared to add the ecliptic to his system of silver circles, to see the Sun creep slowly eastward along it, while the Moon and the planets move at various rates in paths close to it, and are daily relentlessly carried westward by the revolution of the sphere.

III. *Meridian Circle and Equatorial.*—Having fixed in mind the above system of circles, and seen the relations between the different kinds of time, the student will wonder of what practical use sidereal time is, and why the horizon—and equator—systems with their arrays of coördinates have been brought into such

prominence. Now is the time to link this knowledge with the meridian circle and equatorial, to show how the former measures right ascension and declination, and how the latter is used to find objects of known right ascension and declination, a sidereal clock being used with each instrument. In case a surveyor's transit is available, equipped with a vertical circle, some of the more ambitious students may be encouraged to determine the latitude of the place of observation by observing the meridian altitude of the Sun or of some star, the declination of the celestial object being furnished by the teacher. Altitudes and azimuths of celestial objects are easily measured with it, and if the instrument can be fastened to a board or post in such a way that the vertical spindle points toward the north celestial pole, the declinations and hour angles of stars can be measured. In general, however, students cannot be trusted with the use of such an instrument, unless an experienced person is near by. The teacher may, however, use it in the classroom to make the systems of coördinates more real.

IV. *Eclipses.*—On those occasions when partial or total lunar eclipses occur, it is possible to arouse exceeding interest by having each of the class draw a picture of the passage of the Moon through the Earth's shadow. For this purpose it is only necessary that the teacher obtain from the Nautical Almanac the right ascensions and declinations of the Moon, and of the Earth's centre (as seen from the Sun), at intervals of an hour during the eclipse, and for a short time before and after, together with a few data such as the Moon's horizontal parallax, and the semi-diameters of the Sun and Moon.

The details of the process have been previously given in the *Sidereal Messenger* and will readily be worked out by a teacher from the simple statement that a circle representing the Earth's shadow is drawn on cross-section paper, and the position of the Moon with reference to this is plotted for the beginning of each hour, from a knowledge of the difference of right ascension and declination of the centre of the shadow and the Moon's centre.

The students must be given very explicit directions, but will be easily led to make pictures of sufficient accuracy to enable them to predict within a very few minutes the times of the phases of the eclipse, and to show the appearance of the Moon at any time. To draw a picture of a solar eclipse, on the same plan, is a more difficult matter, since the teacher will have to compute the apparent place of the Moon as affected by parallax. The effect of parallax on the position of the Sun may be neglected. Before at-

tempting such work with reference to any particular eclipse the teacher will do well to consider the probability of cloudy weather which would prevent the consummation of the students' enjoyment of the eclipse.

V. *Special Observations.*—While all the class should do the constellation work, special observations may be assigned to particular members of the class, to be made and reported upon. Occultations of stars sufficiently bright to be observed with an opera-glass or spy-glass happen every few days, and the times of their disappearance may be noted. Observations of meteors may be made, even though they be as simple as counting the number visible in an hour during one of the November showers. The watching of Algol for a single evening, when it drops to a minimum, may change an indifferent scholar into an enthusiast. Explorations of the Milky Way with an opera-glass, under instructions to note the positions of specially attractive regions and describe their peculiarities, will open the mind to the wonderful extent and puzzling structure of the stellar universe, as few other exercises will. Just here the writer begs to make the query as to whether the day is ever coming when opticians will put upon the market small telescopes, say two inches in aperture, of pretty short focus, of moderate excellence, and of low price, so that they may be available for students? When a student is unable or unwilling to pay the price asked for such an instrument it may be profitable for a given school to lay in a small stock of them and rent them to students in successive classes at so low a figure that it will be entirely feasible to insist upon much telescopic work. Much zest may be added to a class-room exercise by having a student report upon the apparent motion and changes of appearance of a sun-spot which he has been watching for a week or ten days. Any student who will use a good spy-glass in studying the Moon from new to full, taking particular note of the terminator, and of the changes caused as the sunlight chases the shadows, is likely to gain an abiding interest in our satellite.

The reader is asked to pardon the writer's prolixity on this subject of observation; but one who questions young people much on the subject of astronomy will soon come to the conclusion that they rarely view the heavens to any purpose, and are apt to follow the example of Bunyan's man with the muck-rake.

VI. *Queries.*—The writer has for some years followed the practice of omitting a review of the text-book at the close of the term, substituting for it a series of two or three hundred questions,

most of which are of very moderate difficulty, but cannot be answered by direct reference to the book without independent thinking. Such questions have stimulated classes without discouraging them, and have had a genuine value which seems to an astronomer to be ridiculously out of proportion to their simplicity. Some specimens of these questions are subjoined.

1. Do stars near the zenith twinkle more violently or less than those near the horizon? Why?

2. Does the clock-work of an equatorial, when adjusted for a star near the equator, need further adjustment to enable it to keep a star near the pole in the field of view?

3. Compute the fractional part of the Sun's radiation which strikes the Earth, knowing the diameter of the Earth to be 8,000 miles and its distance from the Sun to be 93,000,000 miles.

4. If the Earth's axis made an angle of 70° with the plane of the ecliptic, and the Earth rotated as at present, but did not revolve about the Sun, is there any part of the Earth in which there would be no night?

5. When the sidereal time is 9^h find the right ascension of a star which has a west hour angle of 5^h.

6. If the Moon be full about Christmas time will it cross the meridian near the zenith, as seen from your home?

7. If the Moon were as large as the Earth would it ever suffer a total eclipse?

8. Draw two concentric circles, one for the orbit of the Earth the other for that of a superior planet: mark the positions of the Sun, Earth and planet when the planet is in conjunction. Then determine whether the synodic period of the planet is longer than the sidereal.

9. If Mercury were seen in transit would it move from the Sun's western limb towards its eastern limb?

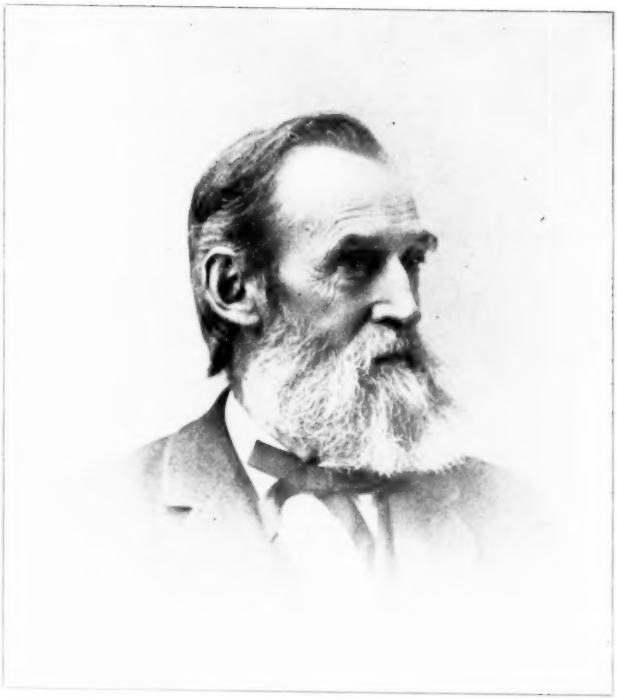
10. Just before inferior conjunction do the cusps of Venus point toward the Sun?

11. Suppose that the ball of Saturn were a perfect sphere of uniform density, and that the ring were a solid circular uniform sheet concentric with the ball. If a satellite pulled the ring so that it was no longer concentric with the ball, would the attraction of the latter then cause the ring to strike its surface?

12. If the shadow of one of Jupiter's satellites, when crossing his disc, fall upon some portion decidedly brighter than the average, will the shadow look darker in consequence?

13. Do those meteors which meet the Earth, and thus resist its motion, tend to lengthen the year?

PLATE XLI.



Professor Hubert A. Newton.
1830–1896.

14. Do the spectra of solar stars indicate that they are probably more dense than Sirian stars, or less dense?

15. If the Earth were fixed, and the plane of the orbit of a binary star were perpendicular to a line drawn to the star from the observer, would the spectroscope enable us to determine the orbital velocity of either star?

VII. *Essays.*—Occasionally essays, preferably short, may be required of different members of a class, upon special topics which will readily suggest themselves. A few are given herewith.

The Astronomy of the Chinese.
The Ancient Greek Astronomy.
The Debt of Astronomy to the Arabians.
Ancient Ideas of the Shape, Support and Motion of the Earth.
Copernicus.
Kepler.
Galileo.
Newton.
The Herschels (William, Caroline and John).
Invention and Development of the Refracting Telescope.
Astronomical Photography.
Habitability of Other Worlds.
The Characteristics of an Ideal Astronomer.
The Work of the U. S. Coast Survey.
The Making of a Modern Object Glass.
Electricity as a Handmaid of Astronomy.
Usefulness of Astronomy.
History of Clocks and Watches.
The Sun as a Source of Terrestrial Energy.

The above queries and topics are given here by permission of Silver, Burdett & Co., their publishers.

UNIVERSITY OF DENVER.

NORTHERN CIRCUMPOLAR VARIABLES.—I.

J. A. PARKHURST.

FOR POPULAR ASTRONOMY.

The importance of careful observations of variable stars cannot be over-estimated. The number of known variables is now so large that their occurrence can no longer be regarded as accidental, but on the contrary, they occupy an important place in the structure of the universe. The enigma of the Algol type

stars has apparently been completely solved by the spectroscopic discovery of the presence of at least two bodies in the system of Algol, but the eclipse theory fails entirely to account for the changes of the other types of variables. It is to be hoped that the twentieth century will produce some Newton or Kepler, who shall bring order out of the existing chaos and discover the great laws which underlie the phenomena and govern the changes of the variable stars.

It is clear then, that the efforts of observers should be directed towards the accumulation of the best observational data, which may serve like Tycho Brahe's, the Kepler of the future.

To observers in the North Temperate Zone, the Northern Circumpolar Variables offer the most promising field for work. They may be followed throughout the year, and every one of their maxima and minima may be determined. It is evident that a complete knowledge of the changes of one star will be of more value than a partial knowledge of many. The object of this paper and the one to follow it, is to furnish means for identifying these stars, so that intending observers may select lists in accordance with their experience and the aperture at their command. In each table the stars are arranged in the order of their distance from the North Pole.

The data in Table 1 and the first half of Table 2 are taken from Chandler's Third Catalogue of Variable Stars. Table 1 needs no explanation further than that a plus sign after the period indicates the presence of a sine term in the Third Catalogue. In Table 2 the first column repeats the number of the star for reference. Column 2 gives the interval in days by which the minimum precedes the maximum. Columns 3, 4 and 5 give respectively, the number of maxima and minima which have been observed, with the dates included. Columns 6 and 7 give the *first* maximum and minimum in 1897. Columns 8 and 9 give, approximately, the aperture in inches required to observe the maxima and minima. The last column tells in what number of POPULAR ASTRONOMY the chart for the star is given.

In selecting stars from this list it should be borne in mind that very red stars are difficult to observe, so that beginners will have little success with such stars as S Cephei and U Camelopardalis.

In the notes that follow, the matter in quotation marks is taken from the notes in the Third Catalogue. The stars are referred to by their numbers.

5190. "Discovered by Hencke in 1858. Light-curve somewhat irregular." For a resume of the observations since 1891

Northern Circumpolar Variables.

Table 1.

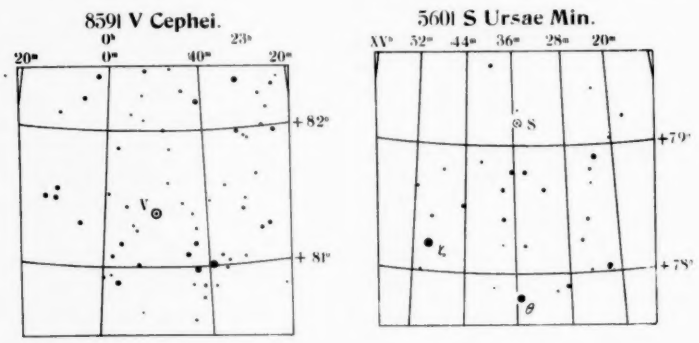
No.	Star.	1900. R. A. h	m	s	Decl. °	′	Redness.	Magnitude. Max.	Min.	Period days.
5190	R Camelopard.	14	25	6	84	17 1	2.1	7.2 — 8.6	11.8 — 13.5	269.5
8591	V Cephei	23	51	44	82	38.1		6 2 — 6.4	6.8 — 7.1	360
320	U Cephei	0	53	23	81	20.2	0	7.1	9.2	2.484
5601	S Ursæ minor.	15	33	27	78	58.3	7	7.4	11.5	328
7779	S Cephei	21	36	28	78	10.3	9.1	7.4 — 9 2	11.5 — 12.3	484
5948	R Ursæ minor.	16	31	18	72	28	3.2	8.6 — 9.0	10.0 — 10.5	Irreg.
432	S Cassiopeæ	1	12	18	72	5.1	6.7	6.7 — 8.6	<13.5	610.5+
3825	R Ursæ Maj.	10	37	34	69	18.0	1.6	6.0 — 8.2	12.6 — 13.2	302.1+
1981	S Camelopard.	5	30	13	68	44.6	7.8	8.3 — 8 5	10.2 — 12	313
7609	T Cephei	21	8	13	68	5.0	6.3	5.2 — 6.8	8.6 — 10.7	387
5955	R Draconis	16	32	23	66	57.8	2.0	6.5 — 8.7	12 — 13	245.6
1623	T Camelopard.	4	30	21	65	56.7	6	7.0 — 8.2	<12	370
116	B Cassiopeæ	0	19	15	63	35.5		>1	?	
1279	U Camelopard.	3	33	12	62	19.4	8.0	7.3	8.8	Irreg.
4557	S Ursæ Maj.	12	39	34	61	38.4	3.2	6.7 — 8.2	10.2 — 11.5	226.1+
4511	T Ursæ Maj.	12	31	50	60	2.3	2.0	6.0 — 8.5	12.2 — 13.0	257.2+

Table 2.

No.	M — m.	Basis of Elements. M.	m.	Dates included.	Prediction 1897. Max.	Min.	Aperture. Max.	Min.	P. A. No.
5190	120:	35	11	1862—95	Sept. 12	May 15	2	6	6
8591	220	6	8	1882, 83, 90—5	Jan. 1	May 21	1	1	37
320			50	1828, 80—93				3	7
5601		4		1890—96	Nov. 10		2	4	37
7779	257	12	5	1789, 1841—93	Apr. 10	Nov. 23	3	6	6
5948							3	3	6
432	300:	14	2	1843, 63—93	No max.	May 9	3	>7	5
3825	107	41	17	1843—95	Feb. 7	Aug. 23	2	6	5
1981	169	5	4	1859, 92—95	Sept. 19	Apr. 3	2	5	37
7609	200	15	10	1789, 1873—94	Dec. 1	May 15	2	3	6
5955	112	20	6	1797, 1858—96	June 8	Feb. 16	2	6	6
1623	175:	4	1	1891—96	Jan. 16	July 30	2	8	37
116		1		1572					5
1279									37
4557	113.0	59	37	1790, 1843—95	Jan. 15	May 4	2	3	5
4511	107.5	38	14	1843, 60—95	May 29	Feb. 11	2	6	5

see Popular Astronomy Vol. III, page 432. This star has been regularly observed by Safarik, of Prague, and Peek, of Rousdon Observatory, England. It is an excellent star for a beginner.

8591. "Discovered by Chandler, 1882; confirmed by Yendell and Sawyer." Yendell has published 5 maxima and 6 minima in the *Astronomical Journal.*



320. A very attractive star. Pickering has published, in *Astrophysical Journal* III. 283, numerous photometric observations of a minimum, 1895, Dec. 3.

5601. "Discovered at Harvard College Observatory, 1895; confirmed by Chandler." An account of its discovery was published by Mrs. Fleming in *Astrophysical Journal* II, 198, together with 33 observations from photographs taken between 1890 March 9 and 1895, June 18. It is now near maximum, so that identification is easy from the chart given in this number. My observations indicate that the minimum precedes the maximum by nearly six months, so that the next minimum is due in May, 1897. The following list of close comparison stars will aid in finding the star when near its minimum:

	Mag.	Co-or. from V. R. A.	Decl.
b	10.6	0.0	− 1.2
d	10.2	+ 0 7	+ 2.3
c_2	11	+ 0.3	+ 6 8
l	11.4	+ 4.3	+ 3.4
m	12.0	− 0.9	+ 1.0
c_1	12	0.0	+ 7.4

7779. "Discovered by Hencke, 1858; light curve flat at maximum." It is number 1929, very red, spectrum type IV, in Krueger's Catalogue of Colored Stars.

5948. "Discovered by Pickering, 1881; confirmed by Chandler. Period 4 to 6 months, very irregular."

432. "Discovered at Bonn, 1861. Light curve variable. A 9.6 mag. star following 20 sec., 2′ S. A 12 mag. preceding 15 sec., 0′.3 S." It is number 104 in Krueger's Catalogue, orange red, spectrum type III. Espin found bright lines in the

spectrum, especially the line F. It will be noticed that only 2 minima are on record, and none have been published since 1891, so there is a pressing need that some one having the use of an aperture of 8 or 10 inches should observe the minima. Observations should begin soon.

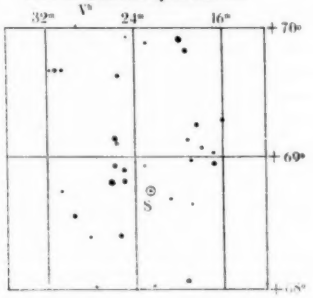
3825. "Discovered by Pogson in 1853. Light curve very variable." Therefore more observations are needed, although many are on record.

1981. "Discovered by Espin, 1891, confirmed by Yendell."

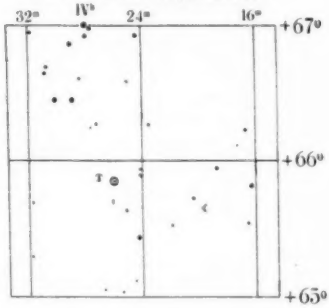
7609. "Discovered by Ceraski, 1878; confirmed by Knott." Krueger, red, spectrum type III. Within reach of 3 inches aperture throughout its period.

5955. "Discovered by Geelmuyden, 1876; confirmed by Hartwig."

1981 S Camelopardalis.

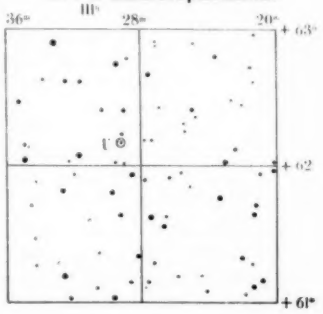


1623 T Camelopardalis.



1623. "Discovered by Espin, 1891; confirmed by Dunér." As far as I know the only minimum observed is that by Dearden, at Trinidad, Col., 1895 July 30. At a low altitude the star went nearly to the limit of a 9½-inch reflector. Observations of minima are needed.

1279 U Camelopardalis.



116. "Tycho's star. Probable place according to Argelander. Possibly identical with a 10.5 mag. star now visible 0'.8 north."

1279. "Suspected by Birmingham, 1871. Independently announced at Harvard College Observatory, 1891."

4557. "Discovered by Pogson, 1853."

4511. "Discovered by Bonn, 1860."

The above is a complete list of the variables in Chandler's Third Catalogue north of declination 60°. In No. II the corresponding data will be given for the stars between 50° and 60°, thus giving all those which can be conveniently followed throughout the year by observers in latitude + 40°.

EVENINGS WITH THE STARS.

MARY PROCTOR.

During the month of January, the Great Bear (*Ursa Major*) is rising above the horizon, in the northeast, and midway between northeast and north are the Pointers. Due north, the Dragon (*Draco*) winds around the Little Bear, its head being close to the horizon. *Perseus*, the Rescuer is nearly overhead, and near him is *Andromeda*, the Chained Lady, and her father King Cepheus, and mother Queen Cassiopeia. Close by the western horizon is *Pegasus*, the Winged Horse, and low down in the northwest is part of the constellation *Cygnus*, the Swan.

Aries, the Ram, and *Triangula*, the triangles are below Andromeda, and in the southwest is *Cetus*, the Whale, and *Pisces* the Fishes, while in the south flows the river (*Eridanus*). Its leading brilliant, *Achernar*, is, however, never seen in the United States. Towards the southeast, glows the radiant Sirius, in the constellation of *Canis* Major, the Great Dog, and between *Canis Major* and *Eridanus* stands Orion, the Hunter, treading on *Lepus*, the Hare, and facing *Taurus*, the Bull. Between southeast and east, is the modern constellation of *Columba*, the Dove.

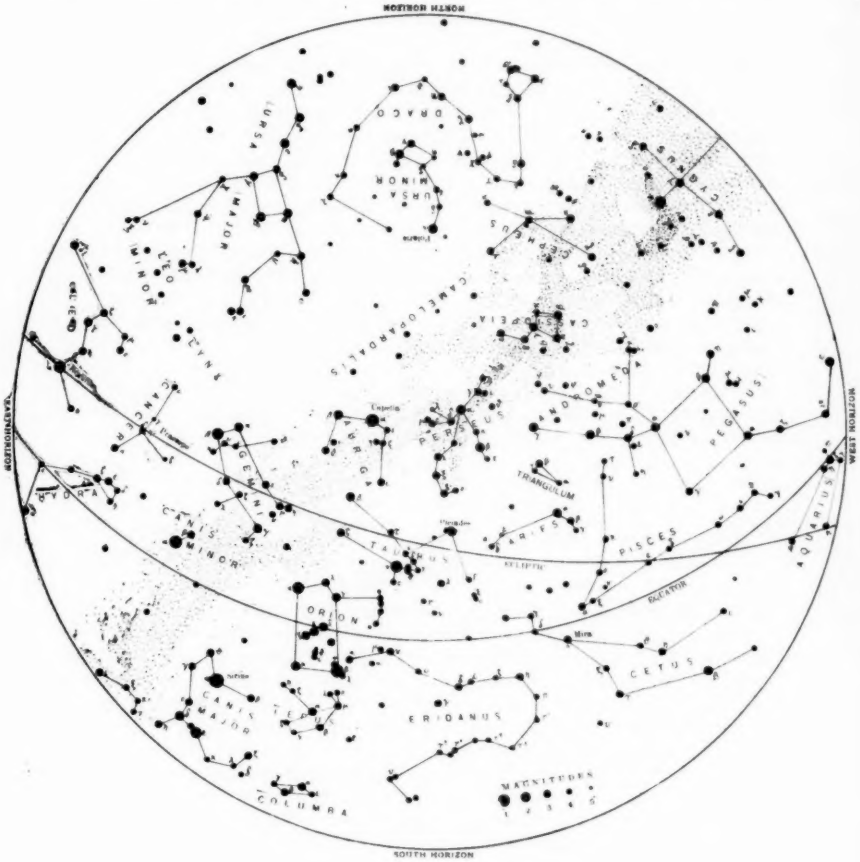
East of Orion is, *Canis Minor*, the Little Dog, and above it *Gemini*, the Twins and *Cancer*, the Crab, with its pretty little cluster called *Præsepe*, the Beehive. Nearly overhead, is the Charioteer (*Auriga*), with the bright *Capella*. Rising in the northeast, is *Leo*, the Lion, the heart star *Regulus* (α) being low down a little north of east, whilst due north, between *Ursa Minor*, the Little Bear, and *Perseus* and *Auriga*, is the Giraffe (*Camelopardus*) standing on its head.

ORION.

"First next the Twins, see great Orion rise,
His arms extended stretch o'er half the skies
His stride as large, and with a steady pace
He marches on, and measures a vast space;
On each broad shoulder a bright star displayed
And three obliquely grace his hanging blade
In his vast head, immersed in boundless spheres,
Three stars, less bright, but yet as great, he bears,
But farther off removed, their splendor's lost;
Thus grac'd and armed he leads the starry host."

This constellation is represented on celestial maps, by the figure of a man in the attitude of defending himself against the attack of *Taurus*, the Bull, the skin of a lion which he holds in his left hand serving for a shield, a huge club in his right hand, and a massive sword in his belt.

From time immemorial, this, constellation has attracted attention, and in the Bible, it is mentioned by Job, when he refers to, His awful majesty who "commandeth the Sun and sealeth up the stars; who alone spreadeth out the heavens, and maketh Arcturus, Orion, and Pleiades, and the chambers of the south," and in another place, the Almighty demands of him—"Knowest thou the ordinances of heaven? Canst thou bind the sweet influence of the Pleiades, or loose the hands



THE CONSTELLATIONS AT 9 P. M., JAN. 1, 1897.

of Orion; canst thou bring forth Mazzaroth in his season, or canst thou guide Arcturus with his sons?" *Mazzaroth* is supposed to represent the twelve signs of the zodiac, which, by their appointed revolutions, produce the various seasons of the year. Arcturus, the name of the principal star in Bootes, here represents

the constellation itself, and the expression *his sons*, doubtless refers to Asterion and Chara, the two greyhounds with which he seems to be pursuing the Great Bear round the North pole. The name of this constellation, is also mentioned in the book of Amos, in the verse: "Seek Him that maketh the seven stars and Orion, and turneth the shadow of death into morning."

Legend.

According to some authorities, Orion was the son of Neptune and Queen Euryale, a famous Amazonian huntress, and possessing the disposition of his mother, he became the greatest hunter in the world. He boasted that there was not an animal on Earth he could not conquer. To punish this vanity, it is said, that a scorpion bit his foot, and caused his death, and that at the request of Diana he was placed among the stars directly opposite the scorpion that caused his death, one setting when the other is rising. For instance, notice the map for April and May, in "Half Hours with the Stars," *Alpha Orionis* is just disappearing over the western horizon, whilst in the southeast the Scorpion's heart (α Scorpii) has just risen.

Orion is one of the largest and most beautiful of the constellations lying southeast of Taurus. A cluster of small stars form the head, two large stars *Betelguese* (α Orionis), and *Bellatrix* (Gamma Orionis) glisten on the shoulders, three bright stars, Delta, Epsilon and Zeta, make the belt, and *Rigel* a star of the first magnitude, is on the left foot, on the west and 15° south of Bellatrix. *Saiph* is a star of the 3d magnitude, in the right knee, 8½° east of Rigel. In this constellation there are seventy-eight stars plainly visible, of which two are of the first magnitude, four of the second, three of the third and fifteen of the fourth. A curve of small stars forms the giant's shield, and the misty light of the great nebula shines on the sword he holds in his hand.

Nebula in Orion.

This is the great nebula in Orion, about which Sir W. Herschel wrote as follows: "I know not how to describe it better than by comparing it to a curdling liquid, or a surfarce strewn over with flocks of wool, or to the breaking of a mackerel sky when the clouds of which it consists begin to assume a curious appearance. It is not very unlike the mottling of the Sun's disc, only if I can so express myself, the grain is much coarser and the intervals darker; and the flocculi, instead of being generally round, are drawn into fine wisps." Barneby, describing the wisps of light visible in this nebula, says they "remind me of the wreaths of smoke which issue from under an extinguisher when putting out the light of a candle;" whilst Struve wrote of it as follows: "The central part of the nebula is in a state of perpetual agitation, like the surface of the sea." In an interesting article, one of a series written for "Popular Science Monthly," by Garrett P. Serviss, on stars seen with a telescope, he gives the following beautiful description of the nebula in Orion: "The trapezium is surrounded by a vast cloud, full of strange shapes. Nowhere else in the heavens is the architecture of a nebula so clearly displayed. It is an unfinished temple whose gigantic dimensions, whilst exalting the imagination, proclaims the power of its builder. But though unfinished it is not abandoned. The work of creation is taking place within its precincts. There are stars apparently completed, shining like gems just dropped from the hand of the polisher, and around them are masses, eddies, currents and swirls of nebulous matter, yet to be condensed, compacted and constructed into suns. It is an education in the nebular theory of the universe, merely to look at

this spot with a good telescope. If we do not gaze at it long and wistfully, and return to it many times with unflagging interest, we may be certain that there is not the making of an astronomer in us."

In the *System of the Stars*, Miss Agnes M. Clerke, writes about it as follows: "It may be that we see in the Orion nebula a great undeveloped cluster on the model of the Pleiades. Nearly a thousand stars were catalogued by Bond in the portion of it (3.36 square degrees in area) examined by him, and his list seems to be practically exhausted. Many of them should, indeed, in Professor Holden's opinion, be accounted rather as nebular condensations than as true stars; but that they will eventually grow to be such, as they slowly absorb the nebulous material now enshrouding them, is a justifiable conjecture. The same process appears already far advanced in the Pleiades, with the result that the stellar now altogether predominates over the nebular element in the compound system. It can scarcely have been always so. The balance inclined perhaps, in the remote past, as decisively the other way as it now does in the Orion nebula. "This extraordinary object has been under effective observation for 234 years, and during the last seventy, has been monographed, mapped, measured, figured and photographed with a diligence worthy of its pre-eminence. Hence, future changes in it, should they take place, must be slight indeed, to escape detection. The multiple star θ Orionis might be called the foundation stone of the entire structure. All the lines of its architecture are laid down with reference to it, and the intimate physical association of the stars with the gaseous stuff surrounding them has been spectrographically demonstrated by Dr. and Mrs. Huggins. This gaseous stuff, although it pervades the trapezium, seems less luminous there than elsewhere. The space about the stars usually forms a sort of oasis of comparative darkness in the midst of a wilderness of piled-up flakes of light. Usually not always." (System of the Stars, pp. 277, 281).

Seen with a good 3-inch telescope, the whole neighborhood of the great nebula will well repay research. The observer may sweep over it any dark night with profit. In the same way, the nebula of Orion seen through an opera glass reveals a mine of wonders.

LEADING BRILLIANTS.

Betelgeuse (α Orionis) is an interesting object when seen through a 3-inch telescope, on account of its color and brilliance, and as one of the most remarkable variables in the heavens. It was first observed to be variable by Sir John Herschel in 1836. At this period its variations were most marked and striking. "This continued until 1840, when the changes became much less conspicuous." In January, 1849, they had recommenced, and on December 5th, 1852, Mr. Fletcher observed α Orionis brighter than Capella, and actually the largest star in the northern hemisphere." In the telescope, Betelgeuse appears as "a rich and brilliant gem," says Lassell, "a rich topaz, in hue and brilliancy differing from any that I have seen."

The name, Betelgeuse," is of Arabic origin, meaning—shoulder-of-the-giant. This star is one of the ten brightest stars north of the equator. In the spectrum of "Betelgeuse" the chemical substances indicated with certainty as constituents of the stars atmosphere, are sodium, magnesium, calcium, iron and bismuth; silver, manganese, thallium, tin, cadmium, antimony, and mercury were more dubiously recognized. The vapor densities of some of these metals are significantly high." (System of the stars, p. 54). According to Secchi's division of stars into types, based upon their spectra, Betelgeuse falls into the third order, which seems to represent a type of suns in which the process of cooling, and the formation of

an absorptive envelope or shell, have gone on so far that we may regard them as appproaching the point of extinction. Betelgeuse shows us a sun that has almost run its course, that has passed into its decline, and that already begins to faint and flicker and grow dim before the on-coming and inevitable fate of extinction. (Astronomy with an opera glass, p. 106. By Garrett P. Serviss).

Rigel, a splendid star of the first magnitude, in the left foot of Orion, belongs to the first order or type which represents suns at an earlier period of development, blazing with the fires of youth and resplendent in the first glow of solar energy. "Rigel belongs to a new generation of the universe; Betelgeuse to the universe that is passing. We may pursue this comparison one step farther back and see in the great nebula, which glows dimly in the middle of the constellation, between Rigel triumphant and Betelgeuse languishing, a still earlier cosmical condition—the germ of suns whose infant rays may illuminate space when Rigel itself is growing dim." (Astronomy with an opera glass, p. 107).

Seen with a telescope, Rigel is a very noted double, and will severely test the observer's telescope if small. The components are well separated, compared with many easier doubles; the secondary is also of the seventh magnitude, so that neither as respects closeness nor smallness of the secondary, is Rigel a difficult object. It is the combination of the two features which makes it a test object. A 3-inch aperture telescope, will certainly show the companion star, which is blue, Rigel being a bright white star. Strangely enough, white stars usually have small blue ones in their vicinity. A distant companion of Regulus is indigo blue, and Flammarion in his catalogue of double stars, (p. 76) gives a list of many others.

There are two bright stars in Orion, virtually devoid of visible proper motion, yet proved to be rushing straight away from our system. Brilliant Rigel is one, and its rate of recession, as determined by Professor Vogel in 1888, is 39 miles a second, and the other is ε (Epsilon) Orionis, the middle star of the belt, traveling at the rate of 35 miles. (System of the stars, p. 341).

Three Stars in the Belt.

But the three stars in the belt, are objects of special interest, and they are usually distinguished by the name of the *Three Stars*, as there are no other stars in the heavens resembling them in position and brightness. Sometimes they are called the *Magi* or the *Three Kings*, because they point out the Hyades and Pleiades on one side, and Sirius, or the dog-star on the other. In Upper Germany they are called the *Three Mowers*, but the most common appellation for them, is the *Ell and Yard*. We are told, that they derive this name from the circumstance, that the line which unites the three stars in the belt, measures just 3° in length, and is divided by the central star into two equal parts, like a yard-stick; thus serving as a graduated standard for measuring the distances of the stars from each other. When therefore, any star is described as being so many degrees from another, in order to determine the distance, it is recommended to apply this rule. (Geography of the Heavens, pp. 57, 58, Burritt).

Delta, the northernmost star of the belt, also known as Mintaka, is a wide double, when seen through a 3-inch telescope. The primary is of the second magnitude, the secondary of the seventh, both being white. This star is on the meridian, the 24th of January, and at this time is almost exactly over the equator.

Epsilon, the second or middle star in the Belt has a distant blue companion and is nebulous.

Zeta, the lowest star in the Belt, is a close double when seen with a 3-inch

telescope, the components being nearly equal, and about 2½″ apart. (See Plate III. p. 47, in "Half hours with the Stars" by R. A. Proctor.) With a more powerful telescope, this star is a triple star, according to the observations made by Captain W. Noble, and recorded in his book "Hours with a three-inch telescope," on page 90. If we turn our opera-glass upon the three stars forming the Belt, Garrett P. Serviss tells us, that we will not be likely to undertake to count all the twinkling lights that we shall see, especially as many of them appear and disappear, as we turn our attention to different parts of the field.

"Below the belt will be seen a short row of stars hanging downward and representing the sword. In the middle of this row is the great Nebula of Orion. The star Theta (θ) involved in the nebula is multiple, and the position of this little cluster of suns is such that, they seem to be feeding upon the substance of the nebula surrounding them. Other stars are seen scattered in different parts of the nebula. This phenomenon can be plainly seen with an opera glass. With a good field-glass several fine test objects will be found in the sword. Run your glass along the line of little stars forming the lion's skin, and here you will find some interesting combinations, and a star about fifteen minutes to the northwest accompanied by a seventh-magnitude star of a rich orange hue." (Astronomy with an opera-glass, pp. 108, 109.)

Telescopic Observations.

The trapezium affords a good test for a 3-inch telescope. Large instruments exhibit nine stars, but a good 3-inch glass, shows four distinctly, but only three are visible with smaller apertures. Turn next to the group of three stars forming the head of Orion. Lambda (λ) the northern-most is a triple star, though a 3-inch telescope will only show it as a double. The components are 5″ apart, the colors white and violet. A faint companion may be seen with the full powers of a 3½-inch glass.

We have not explored half the wealth the telescope reveals in the constellation Orion, but during the long winter evenings it is a study for which we would feel well repaid. Double stars, multiple, and stars of varied hue, streamers and clusters, nebulous masses weaving a delicate tracery amid these glowing suns, variable stars now blazing with resplendent light, and anon waning and flickering, a sure sign of coming darkness and extinction.

Lepus, the Hare.

Below Orion, is the constellation of Lepus, the Hare, and it comes to the meridian at the same time, namely, on the 24th of January. It contains nineteen small stars, of which the four principal ones are of the third magnitude. This constellation contains some remarkable doubles. "Among these we may note ξ (Xi), a white star with a scarlet companion, γ (Gamma), a yellow and garnet double, and ι (Iota) a double star, white and pale violet with a distant red companion. The star κ, (Kappa) Leporis, is a rather close double, white with a small green companion. The intensely red star R. Leporis (a variable) is the chief object of interest." (Half Hours with the Stars, p. 43, by R. A. Proctor).

Garrett P. Serviss describes it as follows, in his "*Astronomy with an Opera Glass*," p. 110. "In Lepus, is the celebrated "Crimson Star," which has been truly described as resembling a drop of blood in color—a truely marvelous hue for a sun—but, as it is never brighter than the sixth magnitude, and from that varies down to the ninth, we could hardly hope to see its color well with an opera-glass. Besides the observer would have difficulty in finding it.

LEGEND.

This constellation is situated about 18° west of the Great Dog, which, from the motion of the Earth, seems to be pursuing it, as the Greyhounds do the Bear, round the circuit of the skies. It was one of these animals which Orion is said to have delighted in hunting, and which, for this reason, was made into a constellation and placed near him among the stars.

COLUMBA, THE DOVE.

This constellation, sometimes called Noah's Dove, is situated about 16° S. of the Hare; and is nearly on the same meridian with the three stars in the belt of Orion. It is an insignificant constellation, containing only 10 stars, one of the second, one of the third and two of the 4th magnitudes; of these, Phaet and Beta are the brightest and are about 2½° apart. Beta is known by means of a small star marked Gamma just east of it, whilst Phaet lies on the right and is the principal star in the constellation.

HISTORY.

This constellation is named after the dove which Noah sent out of the ark, "to see if the waters had abated from off the face of the ground, and the dove came in to him in the evening, and lo, in her mouth was an olive leaf plucked off."

"The surer messenger a dove sent forth once, and again to spy green tree or ground whereon his foot may light:
The second time returning, in his bill an olive leaf he brings, pacific sign!"

PLANET NOTES FOR JANUARY.

H. C. WILSON.

Mercury will be evening planet during the first half of the month and may be visible to the naked eye for a few days. Look toward the southwest, pretty close to the horizon, about half an hour after sunset and you may be able to see the planet. After the 15th Mercury will rapidly approach the Sun, reaching inferior conjunction Jan. 22, and after that will be morning planet. On Jan. 4 at $11^h\,42^m$ A. M. Mercury will be in conjunction with the Moon and an occultation may be witnessed from South America. The drawings of Mercury by Messrs. Lowell and Leonard, given in this number of POPULAR ASTRONOMY, are exceedingly interesting. They would seem to prove conclusiveiy that the rotation period of the planet is coincident with the period of revolution about the Sun. This agrees with the conclusion reached by Schiaparelli in 1884 (*Astr. Nach.* Bd. 123, p. 241).

Venus is approaching her greatest distance east from the Sun, aud at the same time increasing in declination, so that during the latter half of the month she will be in quite favorable position for observation. About two-thirds of the illuminated surface is turned toward us. The brilliancy of the planet, now so great as to render it visible even before the Sun sets, will increase during January in the proportion of 93 to 125. Venus will be in conjunction with the Moon, 3° 7′ south of the latter, on Jan. 6 at $1^h\,22^m$ P. M., Central Standard Time. That afternoon will be a good time to look for the planet, to see if it can be detected with the naked eye in full sunlight. The reader must remember that the Moon moves eastward a distance equal approximately to its own diameter each hour and that

the effect of parallax is to depress the Moon toward the horizon. Consequently Venus will not be seen exactly 3° 7′ south of the Moon's center except at a point on the Earth's surface where the Moon is overhead at $1^h\ 22^m$ P. M. Central Standard Time, but it may be looked for within 5° of the Moon all the afternoon of that day at all places in the United States.

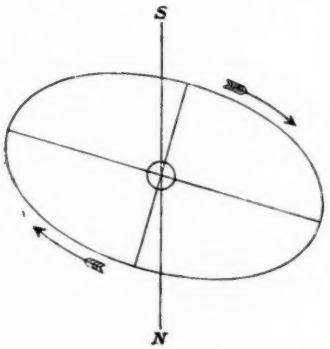
Mars has been at his greatest brilliancy during the past mouth and is now getting into convenient position for evening observation. Mars and the Moon will be in conjunction at $9^h\ 29^m$ P. M, Jan. 14. The retrograde movement of Mars among the stars has been readily noticeable during December. In January this motion slows up, the planet becomes stationary Jan. 15 and after that moves eastward. It has been reported from Juvisy, France that the "canals" *Ganges*, *Cyclops*, *Cerberus*, *Galaxias*, *Brontes*, *Orcus* and *Euphrates* appeared double in November.

Jupiter rises in the northeast between 9 and 10 o'clock in the evening but is not in position for observation until after midnight. Jupiter and the Moon will be in conjunction Jan. 21.

Saturn and *Uranus* are morning planets not in good position for observation.

Neptune is at his best now and should be well studied by those having the use of powerful telescopes in steady atmosphere. Nothing is known as to the rotation period of the planet. The disk of the planet is so small that it is extremely difficult to see, much more so to identify any markings. Neptune is in the eastern part of Taurus. The right ascension of the planet Jan. 1, is $5^h\ 9^m\ 33^s$ and the declination north 21° 31′. The motion is very slow westward.

Elongations of the Satellites of Neptune.



East.

Jan.	2	1.5 A. M.
	7	10.6 P. M.
	13	7.7 "
	19	4.8 "
	25	1.9 "
	31	11.0 A. M.

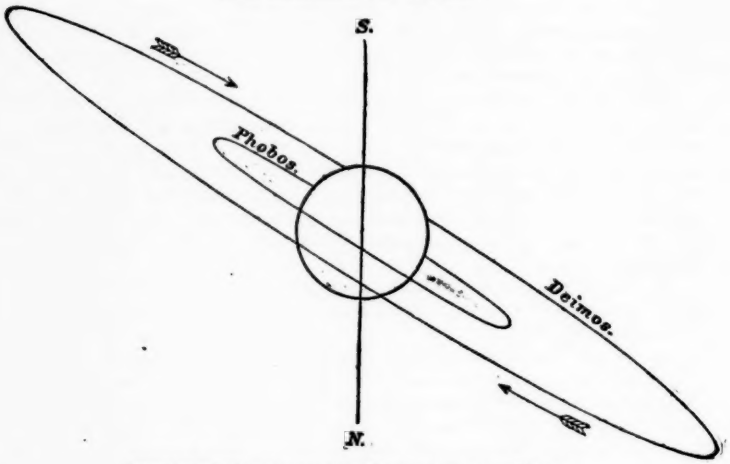
West.

Jan.	4	12.0 Midn.
	10	9.2 P. M.
	16	6.3 "
	22	3.4 "
	28	12.5 "

The Moon.

		Phases.	Rises. (Local Time.) h	m	Sets. h	m
Jan.	2	New Moon	7	29 A. M.	3	47 P. M.
	10	First Quarter	10	52 "	1	1 A. M.
	18	Full Moon	4	46 P. M.	8	8 "
	25	Last Quarter	12	24 A. M.	10	23 "

The Satellites of Mars.



APPARENT ORBITS OF THE SATELLITES OF MARS.

PHOBOS.

		h	m		
Jan.	1	4	26	P. M.	W
	1	18	16	"	E
	2	3	24	"	W
	2	7	14	"	E
	2	11	4	"	W
	3	6	12	"	E
	3	10	2	"	W
	4	5	10	"	E
	4	8	59	"	W
	5	4	6	"	E
	5	7	56	"	W
	5	11	46	"	E
	6	6	54	"	W
	6	10	44	"	E
	7	5	52	"	W
	7	9	42	"	E
	8	4	50	"	W
	8	8	39	"	E
	9	3	47	"	W
	9	7	37	"	E
	9	11	26	"	W
	10	6	34	"	E
	10	10	24	"	W
	11	5	32	"	E
	11	9	21	"	W
	12	4	30	"	E
	12	8	19	"	W
	13	3	27	"	E
	13	7	17	"	W
	13	11	6	"	E
	14	6	14	"	W
	14	10	4	"	E
	15	5	12	"	W
	15	9	2	"	E
	16	4	10	"	W
	16	8	0	"	E

PHOBOS, CON'T.

		h	m		
Jan.	16	11	50	P. M.	W
	17	6	58	"	E
	17	10	47	"	W
	18	5	55	"	E
	18	9	45	"	W
	19	4	53	"	E
	19	8	43	"	W
	20	3	51	"	E
	20	7	40	"	W
	20	11	30	"	E
	21	6	38	"	W
	21	10	28	"	E
	22	5	36	"	W
	22	9	26	"	E
	23	4	34	"	W
	23	8	24	"	E
	24	3	32	"	W
	24	7	21	"	E
	24	11	11	"	W
	25	6	20	"	E
	25	10	9	"	W
	26	5	17	"	E
	26	9	7	"	W
	27	4	15	"	E
	27	8	5	"	W
	27	11	55	"	E
	28	7	3	"	W
	28	10	53	"	E
	29	6	0	"	W
	29	9	50	"	E
	30	4	58	"	W
	30	8	48	"	E
	31	3	56	"	W
	31	7	46	"	E
	31	11	36	"	W

DEIMOS.

		h	m		
Jan.	1	1	45	P. M.	E
	2	8	2	"	E
	4	5	28	"	W
	5	11	45	"	W
	6	2	54	"	E
	7	9	11	"	E
	9	6	37	"	W
	11	12	54	A. M.	W
	11	4	3	P. M.	E
	12	10	21	"	E
	13	1	30	"	W
	14	7	48	"	W
	16	2	5	A. M.	W
	16	5	15	P. M.	E
	17	11	33	"	E
	18	2	42	"	W
	19	9	0	"	W
	20	3	9	"	E
	21	6	27	"	E
	23	12	46	A. M.	E
	23	3	56	P. M.	W
	24	10	15	"	W
	25	1	24	"	E
	26	7	43	"	E
	28	2	2	A. M.	E
	28	5	10	P. M.	W
	29	11	29	"	W
	30	2	38	"	E
	31	8	57	"	E

Occultations Visible at Washington.

Date 1897.	Star's Name.	Magnitude.	IMMERSION. Washington M. T.	IMMERSION. Angle from N pt.	EMERSION. Washington M. T.	EMERSION. Angle from N pt.	Duration.
			h m	°	h m	°	h m
Jan. 13	18 Tauri	6 3	6 42	67	8 12	251	1 30
18	δ Cancri	4.0	18 33	80	19 16	330	0 43

Ephemeris for Physical Observations of Mars.

(From *Monthly Notices, R. A. S.*, April, 1896.]

Greenwich Noon.	Position Angle of Axis.	Areographic Latitude Center of Disk.	Areographic Longitude Central Meridian.	Passage of Zero Meridian. (Cen. St'd Time.)
	°	°	°	h m
Jan. 1	326.03	— 6.68	235.48	2 31 P. M.
3	325.89	6.86	217.57	3 44 "
5	325.77	7.01	199.62	4 58 "
7	325.68	7.13	181.62	6 12 "
9	325.61	7.22	163.57	7 26 "
11	325.55	7.29	145.47	8 40 "
13	325.52	7.33	127.32	9 54 "
15	325.50	7.34	109.12	11 9 "
17	325.51	7.33	90.88	12 25 A. M.
19	325.53	7.29	72.59	1 2 "
21	325.57	7.23	54.26	2 17 "
23	325.62	7.14	35.88	3 33 "
25	325.69	7.03	17.46	4 48 "
27	325.78	6.91	359.00	6 4 "
29	325.88	6.76	340.51	7 20 "
31	326.00	— 6.60	321.98	8 36 "

VARIABLE STARS.

J. A. PARKHURST.

Maxima and Minima of Long Period Variables.

1897 March.

MAXIMA.	Day	MAXIMA Cont.	Day	MAXIMA, Con't.	Day
22 V Sculptoris	16	4407 R Corvi	3	7431 S Delphini	15
294 W Cassiopeæ	30:	4896 T Centauri	8	7560 R Vulpeculæ	29
893 U Ceti	18	5037 RR Virginis	9	7999 X Aquarii	3
976 T Arietis	29	5070 Z Virginis	7	MINIMA.	
1944 S Orionis	23	5157 S Bootis	23		
2080 R Columbæ	26:	5430 T Libræ	23*	114 S Ceti	2
2100 U Orionis	18	5438 Y Libræ	21:	2478 R Lyncis	15
2258 V Aurigæ	27	5504 S Coronæ	13	4521 R Virginis	15
2676 U Monocerotis	4	5566 RU Libræ	16:	5758 X Herculis	7
2742 S Geminorum	26	5931 S Ophiuchi	7	6062 RR Scorpii	3:
2815 U Geminorum	29:	6044 S Herculis	7	7404 R Microscopii	18
3170 S Hydræ	24	6794 R Lyræ	9		
3567 V Leonis	28	7242 S Aquilæ	12		
3637 S Carinæ	9	7266 RT Sagitarii	18		

* Chandler's ephemeris gives March 19, as the date of maximum of 5430 T Libræ, but the elements call for the 23rd.

Minima of the Variable Stars of the Algol Type.

[Given to the nearest hour in Greenwich Mean Time.]

U CEPHEI.

1897.

	d	h
Feb.	1	23
	4	10
	6	22
	9	10
	11	22
	14	10
	16	21
	19	9
	21	21
	24	9
	26	21

ALGOL.

Feb.	1	16
	4	13
	7	10
	10	7
	21	18
	24	15
	27	12

TAURI.

Feb.	4	15
	8	14

λ TAURI CONT.

1897.

	d	h
Feb.	12	13
	16	11
	20	10
	24	9
	28	8

R CANIS MAJ.

Feb.	1	11
	2	14
	3	18
	4	21
	8	7
	9	10
	10	13
	11	16
	12	20
	17	9
	18	12
	19	15
	20	19
	25	8
	27	14
	28	17

S CANCRI.

1897.

	d	h
Feb.	19	13

S VELORUM.

Feb.	9	0
	14	22
	20	21
	26	19

δ LIBRAE.

Feb.	3	13
	5	21
	10	13
	12	21
	17	12
	19	20
	26	20

U CORONAE

1897.

	d	h
Feb.	2	12
	5	23
	9	10
	12	21
	19	18
	26	16

U OPHIUCHI.

Feb.	4	0
	4	20
	5	16
	9	21
	10	17
	14	21
	15	18
	19	22
	20	18
	21	14
	24	23
	25	19
	26	15

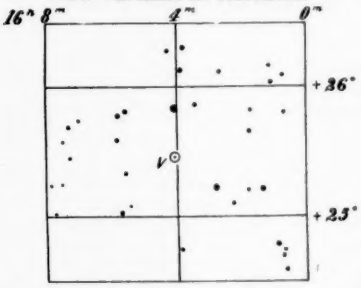
The ephemeris is computed for POPULAR ASTRONOMY from the elements given in Chandler's Third Catalogue. For the Algol type stars I have given all the minima which occur in the night hours in American and European longitudes, when the star is above the horizon. In the long period ephemeris all the stars are given whose periods are greater than 40 days.

Rev. Thomas D. Anderson, of Edinburgh, is having wonderful success in the discovery of new variables. His latest announcement is in *Astronomische Nachrichten* No. 3384. He found a star in the constellation Hercules which faded from 9.1 magnitude 1895 August to less than 10 magnitude Oct. 16 of the same year. The position of the star for 1855 is

R. A. $16^h\ 4^m.1$ Decl. $+25°\ 28'$

The star was invisible to him, below the 10th magnitude, from the latter part of July 1896 till Sept. 28, when he found it 9.8 magnitude. This star is in the limits of the constellation Corona Borealis according to Proctor's atlas. Mr. P. S. Yendell has confirmed the variability of several of Anderson's discoveries within the last year or two. The accompanying chart shows the position of the new variable.

New Variable in Hercules.



A New Observatory with an Unique Programme.—Dr. Friedrich Krueger, formerly of the Kiel Observatory and later of the Bamberg Observatory is to be the director of a new Observatory at Rössgen, Saxony. It will be provided with a refractor of 6.8 inches aperture, with visual and photogrophic objectives. The plan of work includes the formation of a photometric catalogue of colored stars, photometric determination of comparison stars for variables, and the construction of star charts, by the aid of photography, of regions containing variables. Dr. Kreuger's work on colored stars at Kiel and Bamberg has been eminently successful, and the programme marked out will doubtless result in much useful work being accomplished.

COMET NOTES.

Discovery of a New Comet *g* 1896 (Perrine).—A new comet was discovered by Mr. C. D. Perrine at Lick Observatory on December 8. It was then in the southern part of the constellation Pisces. Its motion is southeasterly toward the constellation Eridanus. The comet is telescopic, easily seen with a 4 or 5-inch instrument. It has a small well defined nucleus and a short faint tail. The comet was observed at Northfield Dec. 11 and 12.

Comet *g* 1896 (Perrine).—This comet was discovered about 11:30 o'clock on the evening of December 8th in the constellation Pisces. Its position at $20^h\ 29^m\ 48^s$ Gr. M. T. was R A. $0^h\ 52^m\ 26^s.70$, Decl. $+6°\ 24'\ 51''.9$. It was moving rapidly east and more slowly south.

The comet was fairly bright, being about equivalent to a star of 8 magnitude. In the 4-inch comet seeker it appeared round with a well defined central condensation. In the 12-inch equatorial the comet was about 5′ in diameter and showed a stellar nucleus. The nebulosity surrounding the head did not appear to be symmetrical but was more sharply defined on the south following side and extended in the shape of a broad fan on the north preceding side. This fan-like extension could not be traced for any considerable distance. The air has generally been full of haze since so that I have not been able to see the fainter nebulosity about the head at all.

Observations were secured on the 9th and 10th also, on the latter date with difficulty, owing to thick haze, and from these three observations Professor Hussey and I have deduced the following system of parabolic elements:

ELEMENTS.

$$\left.\begin{aligned} T &= \text{November } 25.6659 \\ \omega &= 164°\ 36'\ 5'' \\ \Omega &= 243\ \ 48\ \ 40 \\ i &= \ 16\ \ 26\ \ 29 \end{aligned}\right\} 1896.0$$

$$\log q = 0.06220$$

Residuals $(O-C)$: $\Delta\lambda' \cos\beta' = -1''$; $\Delta\beta = +3$

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

1896	App. α h m	App. δ ° ′	log r	log Δ	Br.
Dec. 14.5	1 32.3	+4 6	0.0765	9.540	0.89
18.5	1 59.4	+2 41	0.0828	9.561	
22.5	2 24.8	+1 29	0.0901	9.589	
26.5	2 48.2	+0 32	0.0982	9.613	0.57

Mt. Hamilton, December 14, 1896. C. D. PERRINE.

Comet *f* 1896.—This comet is moving west and south and will soon be lost in the Sun's rays. On February 8 it passes perihelion and about that time should emerge from the twilight and become visible in the morning. In the early part of April the Earth and comet come nearer together than at any time previously and hence the comet will be seen to much better advantage, but its orbit is so situated that it goes to within about 10° of the south pole and in consequence will be seen best by southern observers.

An observation on December 9 shows the comet to be following my second orbit (in December number of POPULAR ASTRONOMY) reasonably well, the residuals O — C being: $\alpha + 1^s.6$ $\delta + 37''$

The following ephemeris is from these elements and while not so trustworthy as if based upon a later orbit should be sufficient for finding purposes.

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

1897.		App. α	App. δ	log. Δ	Br.
		h m	° ′		
Feb.	1.5	19 48.5	− 16 17	0.291	1.8
	5.5	48.4	17 45	0.280	2.0
	9.5	48.3	19 18		
	13.5	48.1	20 57	0.252	2.2
	17.5	47.8	22 44		
	21.5	47.4	24 41	0.215	2.5
	25.5	46.8	26 49		
Mar.	1.5	46.0	29 13	0.170	2.9
	5.5	44.8	31 55		
	9.5	43.2	35 1	0.114	3.5
	13.5	40.5	38 35		
	17.5	37.0	42 45	0.050	4.2
	21.5	30.8	47 38		
	25.5	22.5	53 20	9.982	5.2
	29.5	7.2	59 57		
Apr.	2.5	18 38.1	67 21	9.917	6.2
	6.5	17 31.9	74 48		
	10.5	14 50.1	79 16	9.893	6.2
	14.5	11 48.2	75 55		
	18.5	10 29.0	68 22	9.914	5.0
	22.5	9 55.6	60 26		
	26.5	38.9	53 13	9.974	3.4
	30.5	29.7	47 0		
May	4.5	24.5	41 45	0.050	2.1
	8.5	21.6	37 22		
	12.5	9 20.1	− 33 51	0.126	1.4

(Brightness on Nov. 2 taken as unity)

Mount Hamilton, Dec. 15, 1896. C. D. PERRINE.

Giacobini's Comet *d* 1896.—This comet is now exceedingly faint. On Dec. 2 a very faint glow could be seen in its place, with the 16-inch telescope at Northfield, but no measure of the position could be taken. At Nice, France, its position was determined, Nov. 27, $6^h\ 5^m$, local time: R. A. $21^h\ 12^m\ 1^s.0$; Decl. $-12°\ 26'\ 50''$. Professor W. J. Hussey, of Lick Observatory, has computed new elliptic elements of this comet, based upon observations from Sept. 5 to Oct. 29, representing the observed positions very exactly. These give the period of the comet as 9.00 years and place it in the Jupiter family.

ELLIPTIC ELEMENTS OF COMET *d* 1896 (GIACOBINI).

Epoch = 1896 Sept. 5.5 Gr. M. T.

$M = 354°\ 28'\ 7''.88$

$\omega = 139\ 29\ 6\ .34$ }

$\Omega = 192\ 5\ 36\ .82$ } 1896.0

$i = 11\ 32\ 42\ .25$ }

$\varphi = 41\ \ 6\ \ 29\ .13$
$\log e = 9\ 8178836$
$\log a = 0\ 6360428$
$\log \mu = 2\ 5959424$
Period = 3286 days = 9.00 years.

Professor Hussey says in a private letter: "My last observation of the comet was obtained on Dec. 7. Although at that time faint, the comet was distinct and so easily seen that I think it will be possible to follow it a month or two longer if the weather is favorable."

Ephemeris of Comet Brooks (1889 V).

Berlin midn.	R. A.			Decl.			log Δ	Light.
	h	m	s	°	′	″		
Jan. 1	23	52	41.6	+ 0	12	34		
3		56	17.1	0	40	54	0.3078	0.5
5	23	59	54.1	1	9	17		
7	0	3	32.5	1	37	41	0.3180	0.5
9		7	12.2	2	6	6		
11		10	53.1	2	34	30	0.3280	0.5
13		14	35.2	3	2	54		
15		18	18.5	3	31	15	0.3378	0.4
17		22	2.8	3	59	34		
19		25	48.2	4	27	50	0.3475	0.4
21		29	35.6	4	56	2		
23		33	21.9	5	24	10	0.3569	0.4
25		37	10.2	5	52	12		
27		40	59.4	6	20	9	0.3662	0.4
29		44	49.5	6	47	59		
31	0	48	40.5	+ 7	15	43	0.3752	0.4

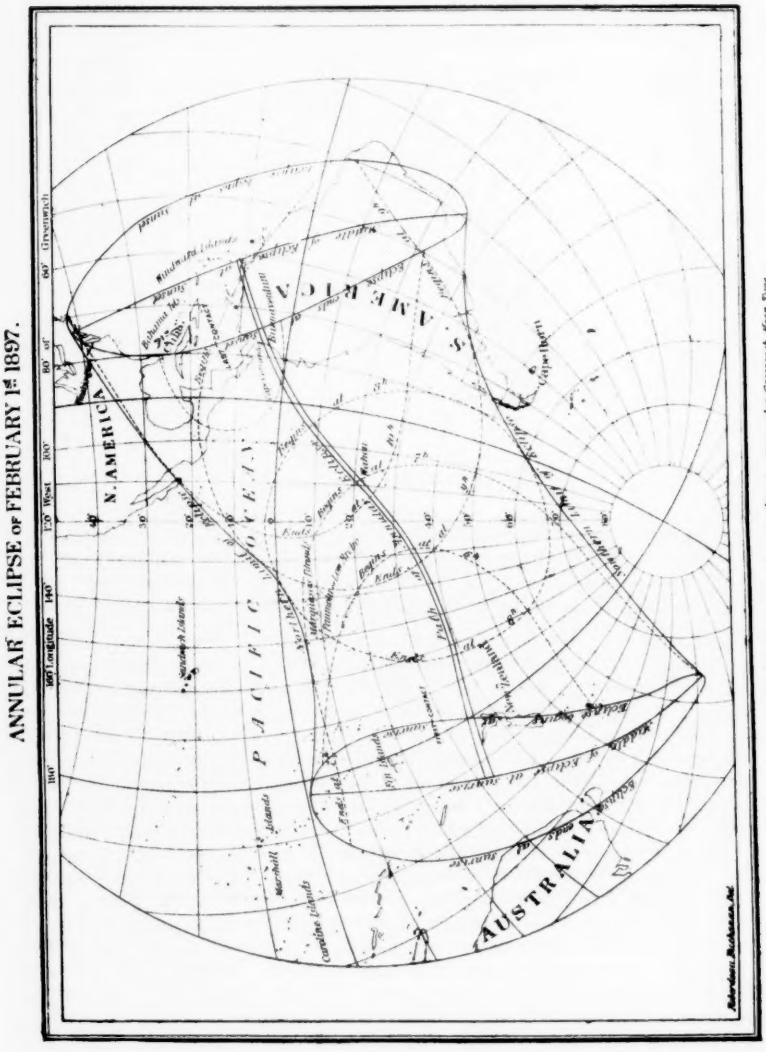
GENERAL NOTES.

Our present plan is to publish every month during the years 1897 and 1898. The price of a years' subscription which will consist of *twelve* numbers is $3.00. For *ten* numbers $2.50 as usual. In 1899 and thereafter volumes will begin with the calendar year and ten numbers only will appear during the successive years.

Death of Dr. Benjamin Apthorp Gould.—With very great regret we announce the sudden death of Dr. Benjamin Apthorp Gould, on Nov. 26. Intending to call on a friend the veteran astronomer was descending the stairs of his residence in Cambridge, when by some accident he fell, striking his head; the shock was so severe that he lived only about two hours and never fully regained consciousness. He had reached the age of 72 years and had been actively identified with the advancement of science for half a century. The loss to astronomy is irreparable and will be felt in all the countries of the world. He stood with the foremost astronomers of our century, and will be ranked in history among the great men of science produced by any age or country. His labors and his virtues have impressed this generation as those of few other astronomers since the days of Laplace, Bessel and Argelander. The loss of this great and good man is indeed keenly felt everywhere, but the example of his illustrious life still lives, and it will inspire his countrymen through coming centuries. Elsewhere in this number, from the pen of two of America's scholarly astronomers are given merited tributes to the life and labors of our lamented Dr. Gould.

Annular Eclipse of the Sun Feb. 1, 1897.—This eclipse will be visible as a partial eclipse only in the eastern and southern part of the United States. The path of the annular eclipse passes across the South Pacific Ocean from the Islands of New Zealand to the northern coast of South America. The accompanying chart shows where the eclipse will be visible. This eclipse possesses little scientific interest and probably no expeditions will be sent out to observe it.

There is but one other eclipse predicted for 1897 an annular eclipse of the Sun July 29, visible in its partial phase throughout the United States.


ANNULAR ECLIPSE OF FEBRUARY 1st 1897.
N. AMERICA
S. AMERICA
PACIFIC OCEAN
AUSTRALIA
NOTE: The hours of beginning and ending are expressed in Greenwich Mean Time

Mascari, Cerulli, and Schiaparelli on Venus' Rotation Period.—Since my paper on Venus was written I have received from Schiaparelli all his papers on the subject and have looked over those of Mascari and Cerulli. These conclude the history of the subject up to the time my paper was written, and the following summations of them should be inserted in their proper place in that paper.

Schiaparelli studied the planet carefully in July, 1895, and saw markings that did not change from day to day in the same places he had seen them in previous years; from which he concluded that the period for the rotation of 224.7 days was now put entirely beyond reasonable doubt. Mascari and Cerulli from their observations supported this period.

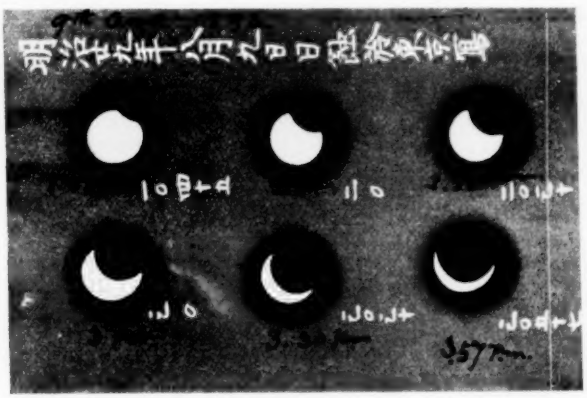
The markings seen by all these observers were of a more or less indefinite character suggesting to them meteorologic change in the form of clouds and so forth affecting to some degree the surface markings beneath. They were, however, sufficiently evident to enable the keen insight of Schiaparelli to detect the rotation period but not sufficiently so to carry conviction or proof of it to others.

The markings seen at Flagstaff were of a different order entirely. They were absolutely distinct and absolutely definite with contours in some cases wonderfully clearly cut against their surroundings; and in good seeing they were always the same in the same places. They therefore showed the physical condition of the planet to be quite different from what had hitherto been supposed and may be said to have put the rotation period beyond even unreasonable doubt.

PERCIVAL LOWELL.

Lowell Observatory, Dec. 10, '96.

Total Solar Eclipse, Aug. 9, 1896, Tokyo, Japan.—By kindness of Percival Lowell, Lowell Observatory, City of Mexico, we are able to present the accompanying reproduction of a photograph of the eclipse of the Sun, Aug. 9, 1896 which was taken in Tokyo, Japan, by one of Mr. Lowell's Japanese friends.



Companion of Sirius—We notice that Mr. Aitken and Professor Schaeberle have been searching for the companion of Sirius, and Professor Holden an-

nounces that they have found it in angle 189°, at distance of 3″.7. The Lick observers say they could not see any companion in the position assigned by Dr. See in Arizona (220°, 5″). The Lowell telescope is now re-mounted in Mexico, and Dr. See will doubtless avail himself of the first favorable opportunity to re-examine the object and he will doubtless give our readers early benefit of his later observations.

The Late Professor H. A. Newton.—On page 236, November number, of the publication, will be found an excellent biographical sketch of the late Professor Newton. Plate XL of this issue is intended to accompany that article. It could not be presented sooner.

A New Spectroscopic Binary in Puppis.—An examination of the Draper Memorial photographs taken at the Arequipa Station shows that the star Lacaille 3105, Argentine General Catalogue 10534, is a spectroscopic binary. The approximate position of this star for 1900 is R. A. $= 7^h\ 55^m.3$, Decl. $= -48°\ 58'$. Its photometric magnitude is 4.50. The lines in its spectrum were first noticed to be double and its binary character discovered by the writer in February, 1895. Professor Bailey was notified and accordingly secured additional photographs and confirmed the binary character of this star. As in the case of μ^1 Scorpii one component is brighter than the other. A discussion of all the photographs of its spectrum here and at Arequipa gives the mean period $3^d\ 2^h\ 46^m$. The times of inferior conjunction can be represented by the formula J. D. 2412777.16 + 3 115 E. At these times the lines are single, for the next thirty-seven hours the lines are double, the fainter component of each having a greater wave length than the brighter component, and being, therefore, towards the red end of the spectrum. The lines then again become single, and after that, for the remainder of the period are again double, the fainter components having shorter wave lengths, and being, therefore, towards the violet end of the spectrum

This is the fourth spectroscopic binary of this class in which both components are bright, the others being ζ Ursa Majoris, β Aurigæ and μ^1 Scorpii.

Harvard College Observatory, Circular No. 14 EDWARD C. PICKERING.
November 17, 1896.

2815 U Geminorum.—Mr. W. E. Sperra's successful observations of this star show how difficult it is to predict its maximum correctly. In the Third Catalogue Dr. Chandler adopted a period of 86 3 days, with the epoch 1895 Oct. 28 (one of Mr. Sperra's maxima) at the same time recognizing the large irregularities. According to this the next maximum would occur 1897 Jan. 2. But the maximum actually happened 1896 Dec 1, as the following observations show.

"On the evening of Nov. 30, though the seeing near the horizon was good, the star was not seen, but nine hours later or next morning the star had almost reached its maximum brightness.

1896 Nov.	30.94	Gr. Mean Time	9 6 mag.
Dec.	1.94		9 2
	5 94		11.5

I had been watching for the star ever since the early part of October."

School of Practical Astronomy.—During the session of 1896-'97, at the University of Virginia, Charlottsville, Va., Prof. Ormond Stone will lecture three times a week on Celestial Mechanics. The effort will be to present the subject in

such a manner that it can be readily comprehended by any one possessing an elementary working knowledge of Differential and Integral Calculus. This course is designed for persons preparing to become astronomers and for students desiring to supplement the work of the school of mathematics.

Chronological Notes.—In noting a slip or two in Young's Astronomy, in the article under the above caption, in this number of the journal, it is not with the slightest intention of casting any reflection on either the work or the man. Both are very near the front line of astronomies and astronomers, respectively. I use this work because of its great excellence, and because it contains exactly the points which I wished to bring up. I cheerfully bear testimony to the excellence of the work and of the man; —even the Sun has spots on it—but they do no harm. In addition to his just celebrity as an observer and a writer, I would say to those who may not know the facts, that he was a patriotic soldier in the war of the rebellion. Professor Young, the undersigned, and four other Ohio professors of mathematics and astronomy were, in one squad, sworn as captains into the military service of the United States, in the early part of June, 1862. It is but truth, also, to say that no other department in college was represented then and there.

The Professor will allow the points I have made, in the same spirit with which these strictures are given. R. W. MCFARLAND.

BOOK NOTICES.

Dr. Boyd's Translation of Briot and Bouquet's Elements of Analytical Geometry of Two Dimensions.—The student of astronomy is often in need of a good work on analytical geometry, and hence it is with real satisfaction that we call attention to the translation by Dr. J. H. Boyd of Briot and Bouquet's celebrated *Lecons de Geometrie Analytique*, just issued by the Werner School Book Company (Chicago and New York).

This comprehensive and magnificent treatise of the French geometers is so well known to those acquainted with the higher branches of modern mathematics that commendation from the writer would be unnecessary if not presumptious, but for those interested primarily in astronomy it may not be inappropriate to add that we are here presented with what is perhaps the best work on analytical geometry in any language. Among the advantages of this splendid work we mention:

(1). The simplicity with which the subjects are introduced, and the extreme elegance and generality with which they are treated—thus making the work suitable for students as well as for the highest mathematicians.

(2). The intimate relation of geometry and analysis and their mutual dependence and utility in treating the various problems of mathematics.

(3). The clear and natural way in which the different systems of coördinates are introduced, and the intimate connection which is shown to exist between analytical geometry and the higher branches of mathematics, such as theory of functions, surfaces, etc.

(4). The practical character of the work, as illustrated by applications of the theories to numerous problems.

(5). The beautiful topography and fine illustrations made use of throughout the text.

(6). The great scope of the work, which treats all the important methods

invented by geometers, and includes the most beautiful discoveries of ancient and modern times.

All the fine qualities which appear in the French edition have been secured in the translation, and the American student is thus placed in possession of one of the most precious works of French science. The book is beautiful as well as profound. The style used in the translation is occasionally affected by the French idiom, but on the whole is very satisfactory, and the translator deserves the thanks of students and teachers and of mathematicians generally for rendering more accessible an invaluable work.

It will unnoubtedly prove of great service to students interested in the more difficult branches of mathematical astronomy. The high character of this treatise in comparison with the mediocrity of most American text books gives us a genuine sigh of relief; the labors of the translator and publisher will surely redound to their lasting credit. T. J. J. SEE.

Lowell Observatory,
City of Mexico, Nov. 24, 1896.

Euclidean Geometry.—The author of this new book is J. A. Gilbert, Professor in the New York Normal School, and its publishers are Messrs. Henry Holt & Company, New York.

The main reason given by the author for the preparation of a new book in the elements of geometry, is that such a book ought to use purely geometric methods. In proportion, even, he thinks that the destruction in the processes of pure geometry should be sharply distingnished from those of arithmetic and algebra. He holds to this view because of pure geometry concerns itself with quantity in the form of continuous magnitude, and develops properties without the aid of number, whether the quantities under consideration are commensurable or incommensurable. When such quantities as the last named are treated by algebra, the method and theory of limits must be used which is less easy of application than that of the pure geometry as exemplified by euclid. In this general view of quantity, the study of its properties, and its measures in geometrical sense, the author is undoubtedly right. We are agreeably surprised in reading considerable portions of this book to find so many themes treated so clearly and so well. The logic of pure geometry appears prominently and at good advantage. The exercises are many and well chosen, and the book as a whole presents a full and useful course in elementary geometry for the needs of the best preparatory schools.

It will be profitable for any teacher of the elements of geometry to read the notes, supplemental parts and the fine print generally. The note on page 18, concerning the parallel axiom of Euclid, illustrates our meaning. There are few teachers of geometry who have spent years at it who will not be both instructed and edified by the perusal of that one page. It will pay to examine this new book thoroughly.

Elementary Solid Geometry and Mensuration, by Henry Dallas Thompson, Professor of Mathematics in Princeton University, published by The Macmillan Company of New York.

The matter of this new book is presented in eight chapters filling 200 pages. The first deals with lines and planes and their intersections. This chapter occupies 28 pages. The second treats of angles of planes and lines in 24 pages concluding with four pages of exercises. The third, polyhedral angles in 12 pages with two exercises. The fourth, polyhedrons, 34 pages with five pages of exercises. The fifth, Cylinders and cones, 12 pages. Sixth, the sphere, fully treated with four pages of exercises. Seventh, conic sections in ten pages and eighth, mensuration of solids of 46 pages.

The author has made a careful selection of the matter for these chapters, leaving out a great deal of that found in many late books, and choosing only that which is essential to the integrity of a thorough course needed for college requirement. The figures are excellent, the exercises abundant, statements clear and concise and the general method of treatment very satisfactory Price $1.25.